2010 PNE/AEROSE-VI
Ocean Validation Campaign Summary

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and

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Sounder Science Team Meeting
Greenbelt, Maryland, USA
4 November 2010

AEROSE Overview

- The **Aerosols and Ocean Science Expeditions (AEROSE)** are a series of trans-Atlantic intensive atmospheric field campaigns conducted aboard the NOAA Ship *Ronald H. Brown (RHB)* (*Morris et al.* 2006).
  - AEROSE-I (March 2004; 4 weeks)
  - PNE*/AMMA*/AEROSE-II (June-July 2006)
    - Leg 1 (4 weeks)
    - Leg 2 (4 weeks)
  - PNE/AEROSE-III (May 2007; 4 weeks)
  - RB-08-03 Interhemispheric Transit descoped mission (Apr-May 2008; 3 weeks)
  - PNE/AEROSE-V (July-August 2009; 4 weeks)
  - **PNE/AEROSE-VI** (Apr–May 2010; 4 weeks)

- As part of the **NOAA/PNE** mission, AEROSE has grown to become one of the most extensive collections of *in situ* measurements of the Saharan air layer (SAL) and associated African dust and smoke outflows over the tropical Atlantic Ocean, including
  - Transport, microphysical evolution and regional impacts
  - Regional atmospheric chemistry and marine meteorology

*AMMA – African Monsoon Multidisciplinary Analysis

*PNE – PIRATA Northeast Extension

PNE/AEROSE Synergism

- **Participating Institutions**
  - Howard University NOAA Center for Atmospheric Sciences (HU/NCAS)
  - NOAA/NESDIS/STAR
  - University of Miami/RSMAS
  - NOAA/ESRL/PSD (formerly NOAA/ETL)
  - NOAA/OAR Atlantic Oceanographic and Meteorological Laboratory (AOML)
  - NOAA Pacific Marine Environmental Laboratory (PMEL)

- **Synergism**
  - **Low Cost – Low Risk**
  - Engages broader science community on specific problems.
  - All parties gain access to all data.
  - AEROSE is a key component of the PNE cruises. Time onboard the *RHB* is at a premium – NOAA is inclined to allocate cruises that make efficient use of resources.

KEY CONTRIBUTORS

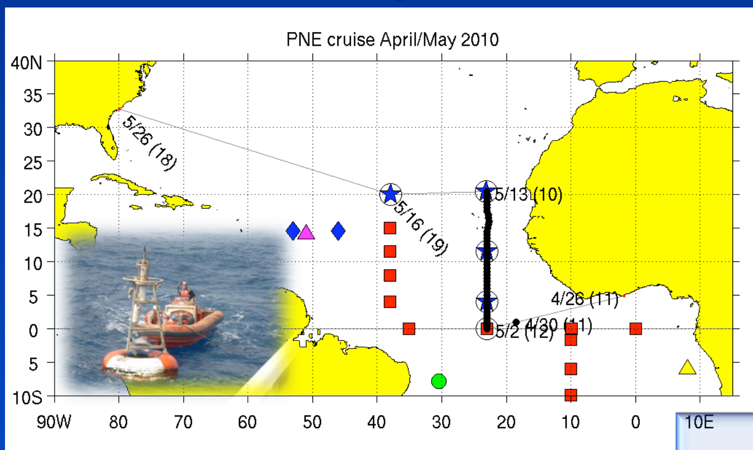
NAME	INSTITUTION	COLLABORATION
N. Nalli, C. Barnet, H. Xie, T. King, G.Guo, M. Divakarla, T. Reale, J. Wei, W. Wolf, M. Goldberg, et al.	NOAA/NESDIS/STAR	RS92 Rawinsondes; CrIMSS/ GOES-R Proxy Data and Pre-Launch EDR Validation; NPROVS
E. Joseph, V. Morris Grad Students	HU/NCAS	Aerosols; Chemistry; Radiation Budget; Ozonesondes; Helium
R. Lumpkin C. Schmid	NOAA/AOML	PNE Chief Scientists; TAO Moorings; CTD, XBTs
P. Minnett, M. Szczodrak, M. Izaguirre	UM/RSMAS	M-AERI Measurements; MW Radiometer; All-sky camera
D. Wolfe B. Otto	NOAA/OAR/ESRL/PSD (formerly NOAA/ETL)	Vaisala sounding system; Surface Flux Measurements; C-Band Radar; Wind Profiler; Sea Space Satellite Uplink
T. Pagano, E. Fetzer **AIRS Science Team** W. Feltz, R. Knuteson	JPL UW/CIMSS	AIRS/IASI validation rawinsonde support ('07,'08) AIRS validation rawinsonde support ('04,'06)

Specific objectives of the *RONALD H. BROWN* cruise

The objectives of this RHB cruise address NOAA's Climate Goal and Weather and Water Goal, and are an explicit NOAA contribution to the PIRATA and AEROSE programs. Specific goals are in the areas of oceanography, marine meteorology, atmospheric chemistry and satellite validation.

AEROSE Ship Tracks to Date

PNE Buoy Mission



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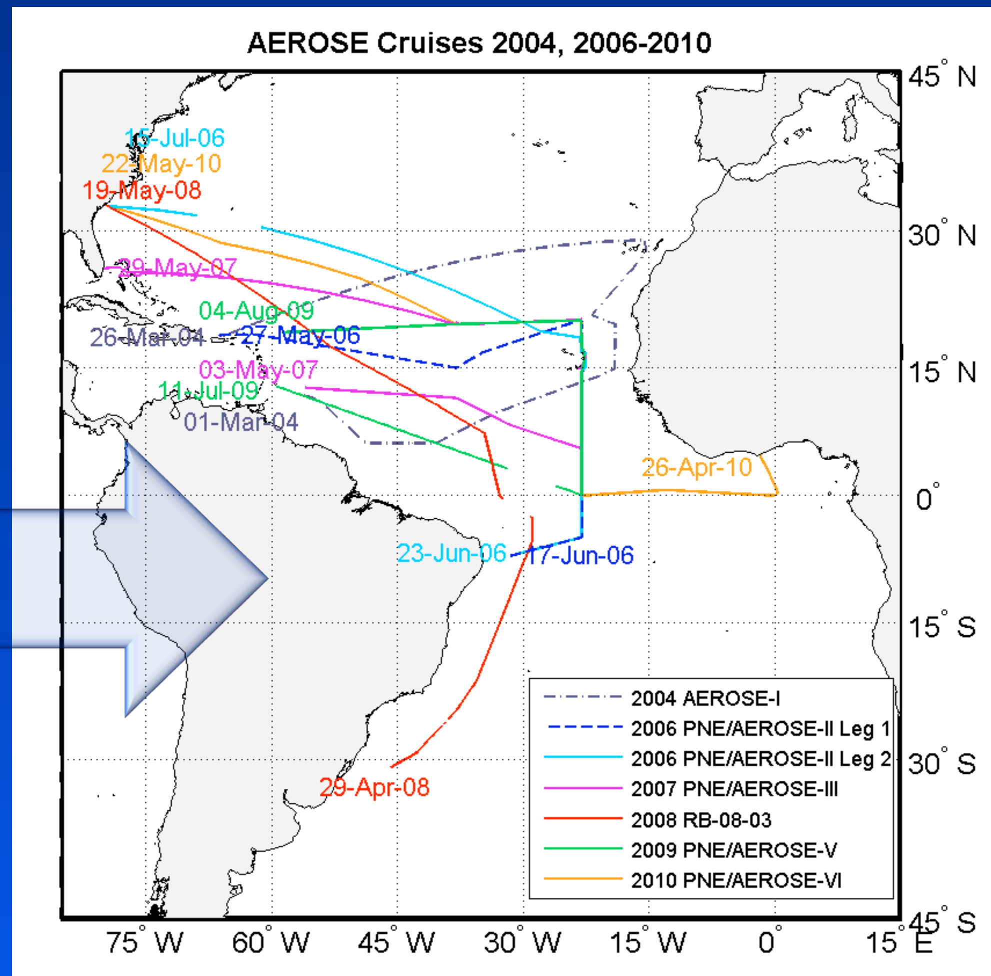
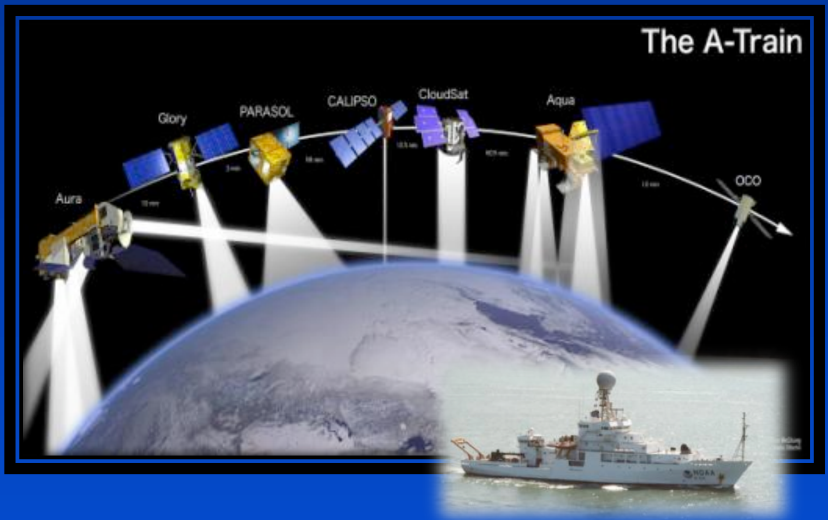
AEROSE Mission



Validation Schemes

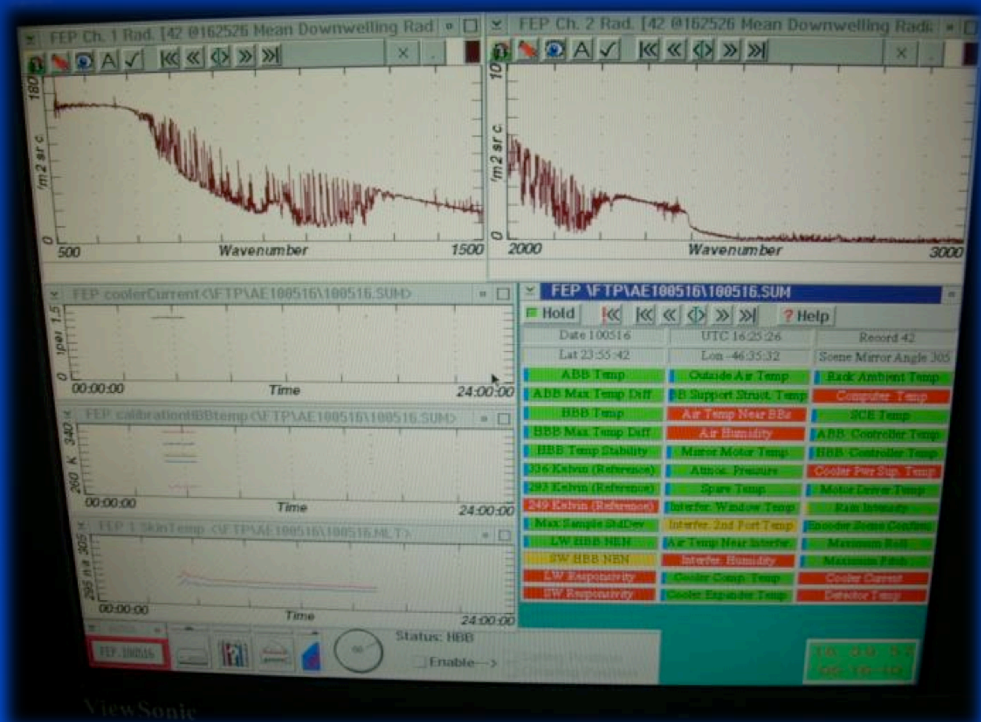
- **Satellite validation schemes**
  - **Operational** *in situ* matchup data (usually **NOAA**)
    - Statistical significance: large matchup data samples can be obtained using (e.g., operational radiosondes over land, and moored buoys); "global" scale
  - **Intensive campaigns (e.g., AEROSE, WAVES, START, JAIVEx)**
    - Simultaneous complementary measurements that can be used to specify key aspects of the atmospheric state
    - Allows focused case studies, including interesting, but more difficult, smaller scale meteorological phenomena (e.g., SAL, aerosols); ships/airplanes only ways to sample over open ocean
  - **Dedicated sites (e.g., GRUAN, ARM, HU/Beltsville)**
    - Research-quality data acquired during overpass times



- **Measurements over the open ocean** are valuable for validation
  - Surface is far simpler to specify and better characterized
  - Oceans are where satellites are expected to make a significant impact (where there is no *in situ* data)

AEROSE

DATA


Wavenumber
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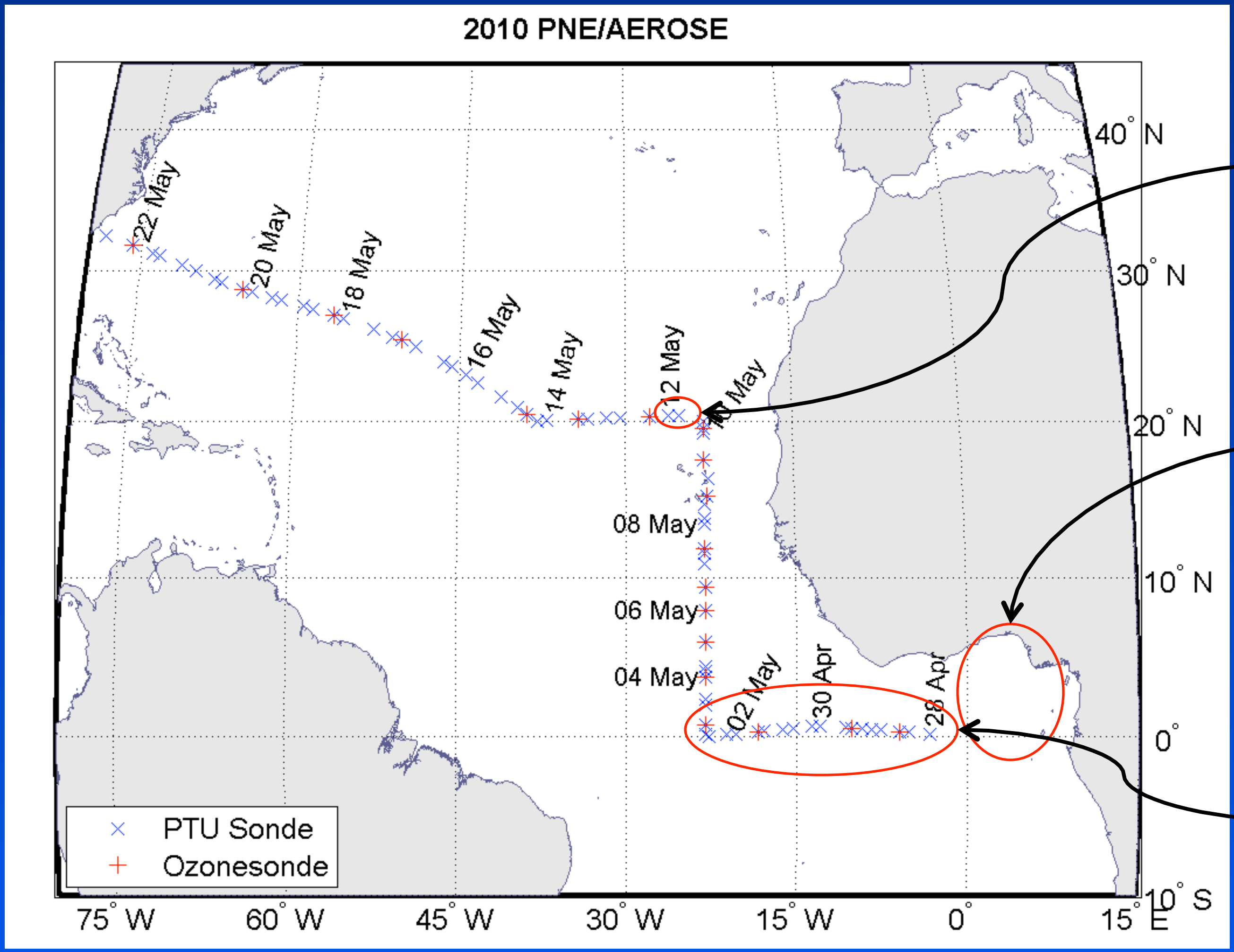
Dedicated Radiosonde Observations: *PTU*, *v*, *z*(*t*), O_3

- **Vaisala RS92 GPS rawinsondes** (RS80/90 in 2004) launched coinciding with AIRS and IASI overpasses
  - Sondes typically 4/day at ~01:30, 09:30, 13:30, 21:30
  - **75** successful ’10 launches
  - **578 PTU soundings** to date
  - **GPS altitude,** *z*(*t*), from RS92 sondes
  - 2004, 2008–2010 ***not*** uploaded into GTS (i.e., **not assimilated**)

- **Ozonesondes** ~1/day during AIRS/IASI overpasses
  - **19** successful ’10 launches
  - **89 O_3 soundings** to date

2010 RAOB Launches



"Focus Day" Matchups

Planning for a quick spin-up time…

…allowed for unique sampling in the Gulf of Guinea.

Marine Atmospheric Emitted Radiance Interferometer (M-AERI)

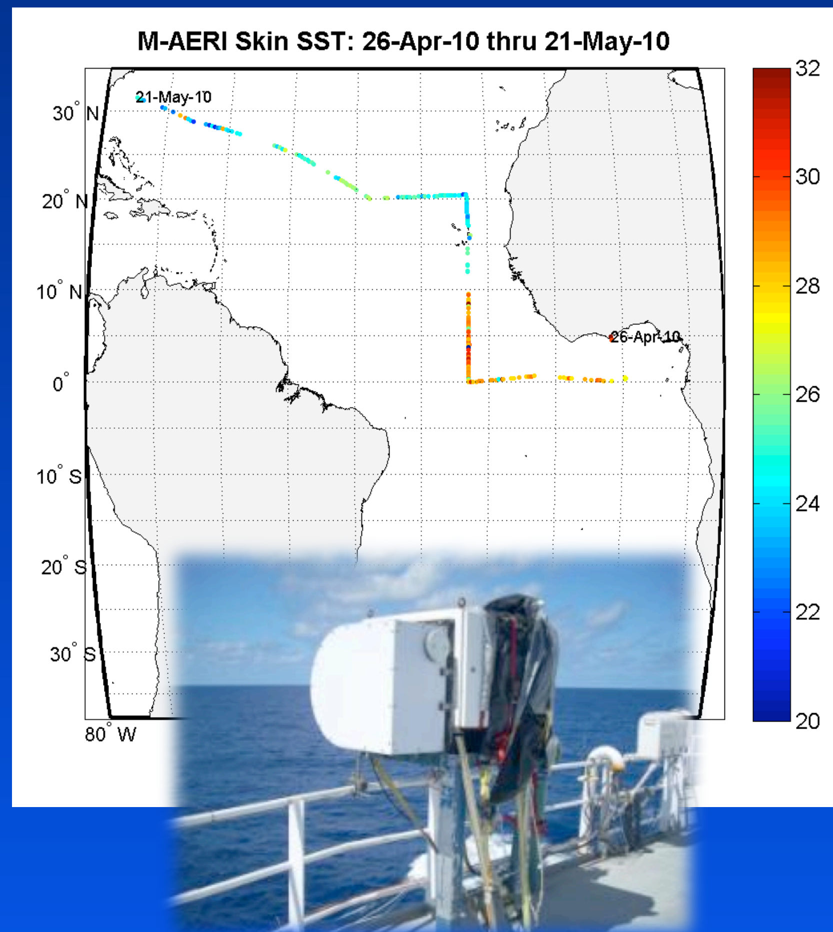
(P. Minnett *et al.*)

- The AEROSE campaigns have all been equipped with M-AERI instruments, **ship-based FTS systems** designed to sample downwelling and upwelling calibrated IR spectra near the surface (*Minnett et al.* 2001).

- **High accuracy calibration** is achieved using 2 NIST-traceable blackbodies (e.g., *Revercomb et al.* 1988).

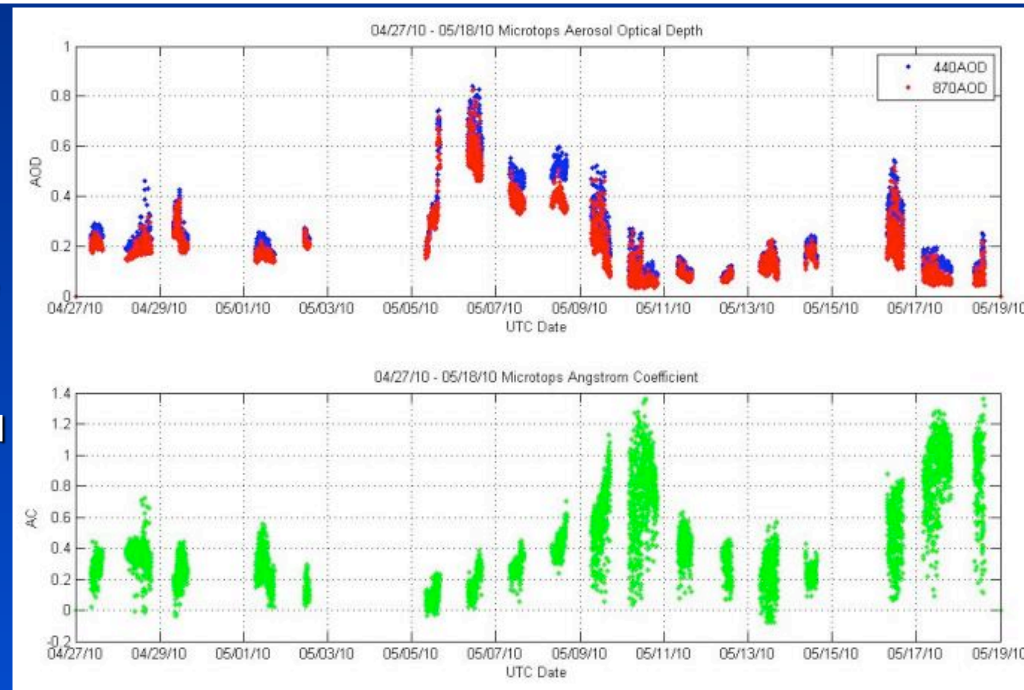
- **Derived products**
  - **High accuracy skin SST** derived from semi-opaque spectral region (~7.7 μm) (*Smith et al.* 1996), a state parameter necessary for forward calculations.
  - Continuous retrievals of lower tropospheric profiles at turbulent time scales (e.g., *Szczodrak et al.* 2007)
  - Retrieval of ocean surface spectral emissivity (e.g., *Hanafin and Minnett* 2005; *Nalli et al.* 2008b)

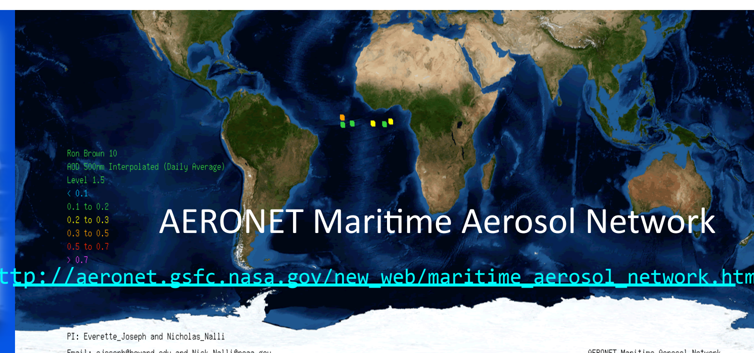
- **M-AERI operated successfully during the 2010 AEROSE-VI** (as well as in 2004, 2006–2008).



Other Shipboard Data

- **Microtops Sunphotometer**
  - Multi-channel instrument that retrieves aerosol optical depth (AOD)
  - **NASA/GSFC AERONET Maritime Aerosol Network.** The MAN measurement and QA methodology for Microtops handheld sunphotometers is applied to retrieve a standardized AOD.
- Broadband pyranometers and pyrgeometers (sfc energy fluxes)
- *In situ* gas & particle measurements
- Ceilometer and microwave radiometer
- All-sky camera
- Research vessel quality meteorological and oceanographic surface measurements





Summary of STAR Proxy Data

		2004	2006	2007	2008	2009	2010
Time Range		Mar 2–Mar 26	May 27–Jul 14	May 6–May 28	Apr 29–May 19	Jul 13–Aug 9	Apr 26–22 May
Space Domain		[35N, 10S; 80W, 10W]			[35N, 35S; 80W, 10W]	[30N, 10S; 80W, 10W]	[35N, 5S; 80W, 0]
RAOB	NetCDF	154	97	96	74	81	(75)
OZONE	NetCDF	0	20	17	16	17	(19)
MAERI	NetCDF	23	37	(19)	23	0	(24)
SEVIRI	NetCDF	624 grans	1056	599	499	663	
AIRS(L1B)	HDF	715 grans	1141	537	620	592	
AIRS(L2-CC)	HDF	730 grans	1122	627	617	587	
AIRS(L2-RetStd)	HDF	703 grans	1141	630	617	584	
AMSU(L1B)	HDF	730 grans	1141	627	590	614	
IASI(L1B)	NetCDF	0	0	30	32	31	
IASI(CCR)	NetCDF	0	0	30	32	31	
IASI(L2)	NetCDF	0	0	30	32	31	
ECMWF							

AEROSE

OF INTEREST TO IR SOUNDING…

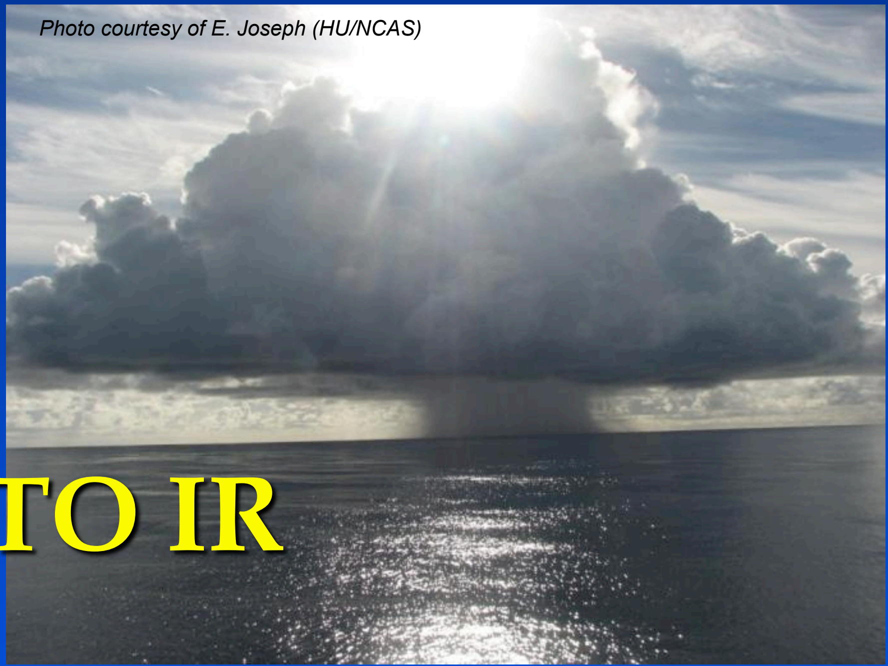
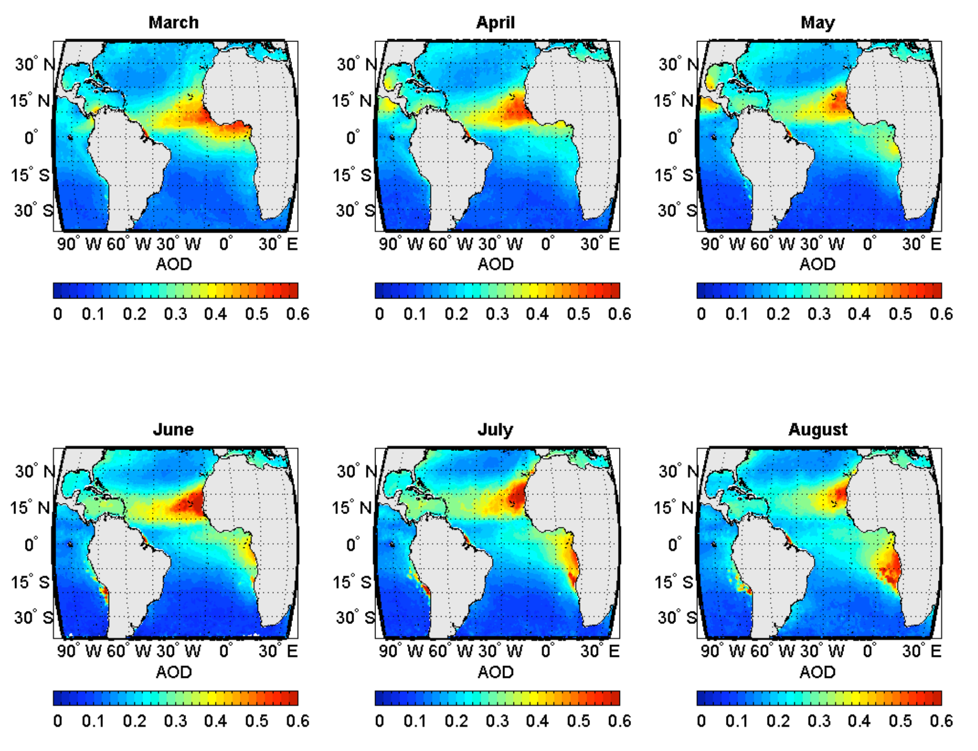


Photo courtesy of E. Joseph (HU/NCAS)

Dust and Smoke Aerosols

- **~100–400 Tg of mineral dust** are injected into the atmosphere from the Sahara annually (*Prospero et al.* 1981).
  - Peaks during NH summer and springtime
  - Coarse-mode aerosols, often transported within easterly trade winds well across the Atlantic north of the ITCZ
  - Westward flow accounts for the 30–50% of the dust output
- **Smoke from biomass burning** from sub-Saharan Africa also contribute large quantities of smaller-sized aerosols.
- These have a significant impact on the meteorology and climate dynamics of the tropical North Atlantic (e.g., radiation balance).
- Due to absorption/scattering, they also **impact infrared radiances**, and thus geophysical retrievals (e.g., *Nalli and Stowe* 2002; *Weaver et al.* 2003).

AVHRR PATMOS-x AOD Climatology



Saharan Air Layer (SAL) and Tropical Cyclogenesis

- The **Saharan air layer (SAL)** is a dry, warm stable, desert air that advects over Atlantic (*Carlson and Prospero* 1972)
  - Enhanced low level temperature inversion
  - Enhanced vertical wind shear associated with midlevel easterly jet
  - Sometimes contains significant levels of Saharan dust
  - Based upon AEROSE SAL cross-sectional observations (e.g., *Nalli et al.* 2005), **the SAL appears to be a persistent special case of a dry air tongue or dry filament phenomenon as described by *Mapes and Zuidema* (1996)** (*Nalli et al.* 2011)
- SAL conditions hypothetically act to suppress hurricane formation over the Atlantic (e.g., *Dunion and Velden* 2004; *Wong and Dessler* 2005; *Evan et al.* 2006).
- LEO and GEO **satellite sounders** and imagers are tools whereby the SAL can be (and is now being) observed synoptically; this is why **satellite validation in this region is highly desirable**.

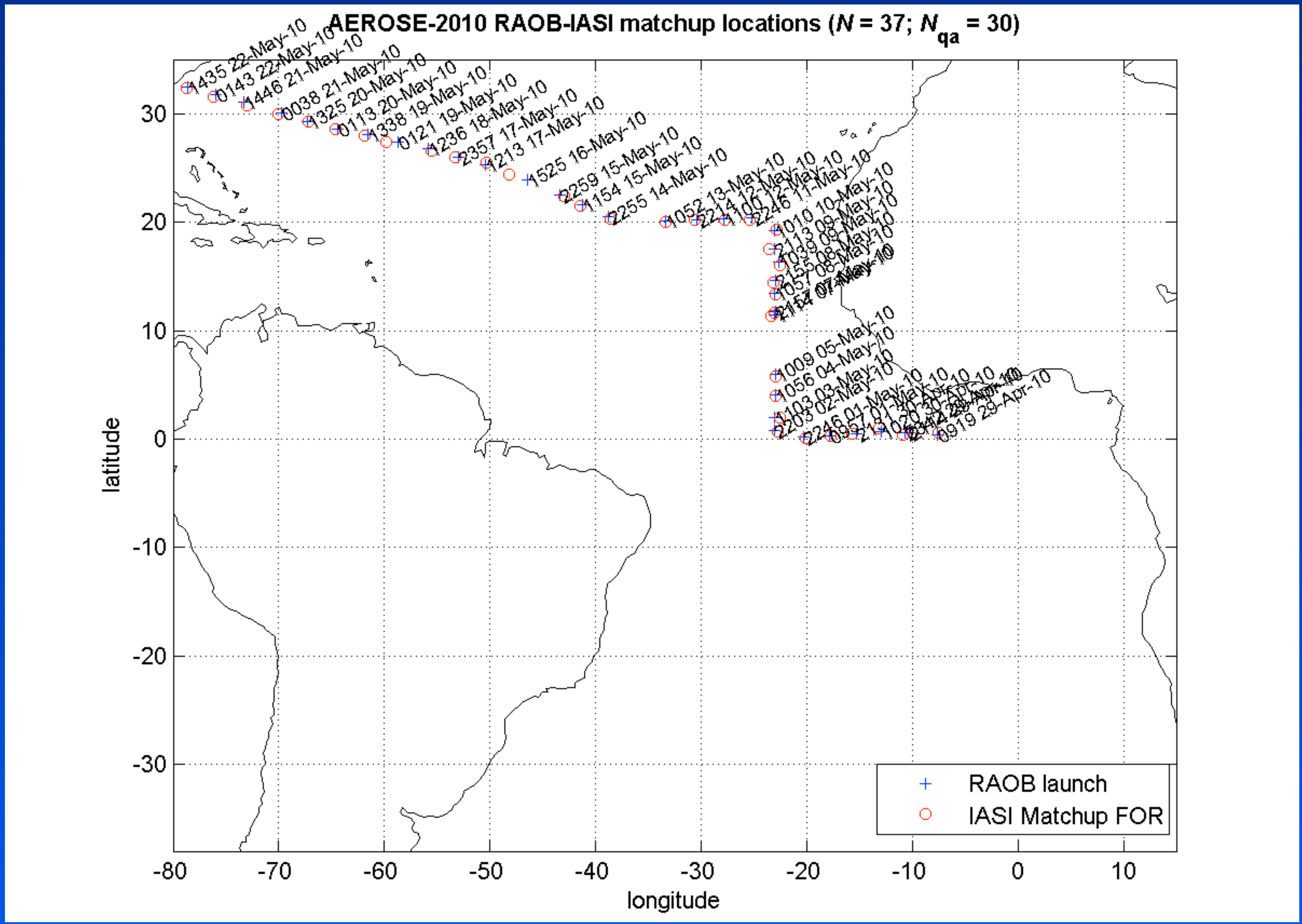
Aerosol Impact on the Chemistry of the Tropical Atlantic Atmosphere

- Surface aerosol-gas interactions and transport
- Tropospheric Ozone Dynamics
  - Smoke aerosol precursors from African and South American biomass burning
    - Horizontal advection via easterlies
    - Vertical transport via tropical deep convection
  - Lightening in deep convection – NO_x formation
  - Stratospheric intrusions

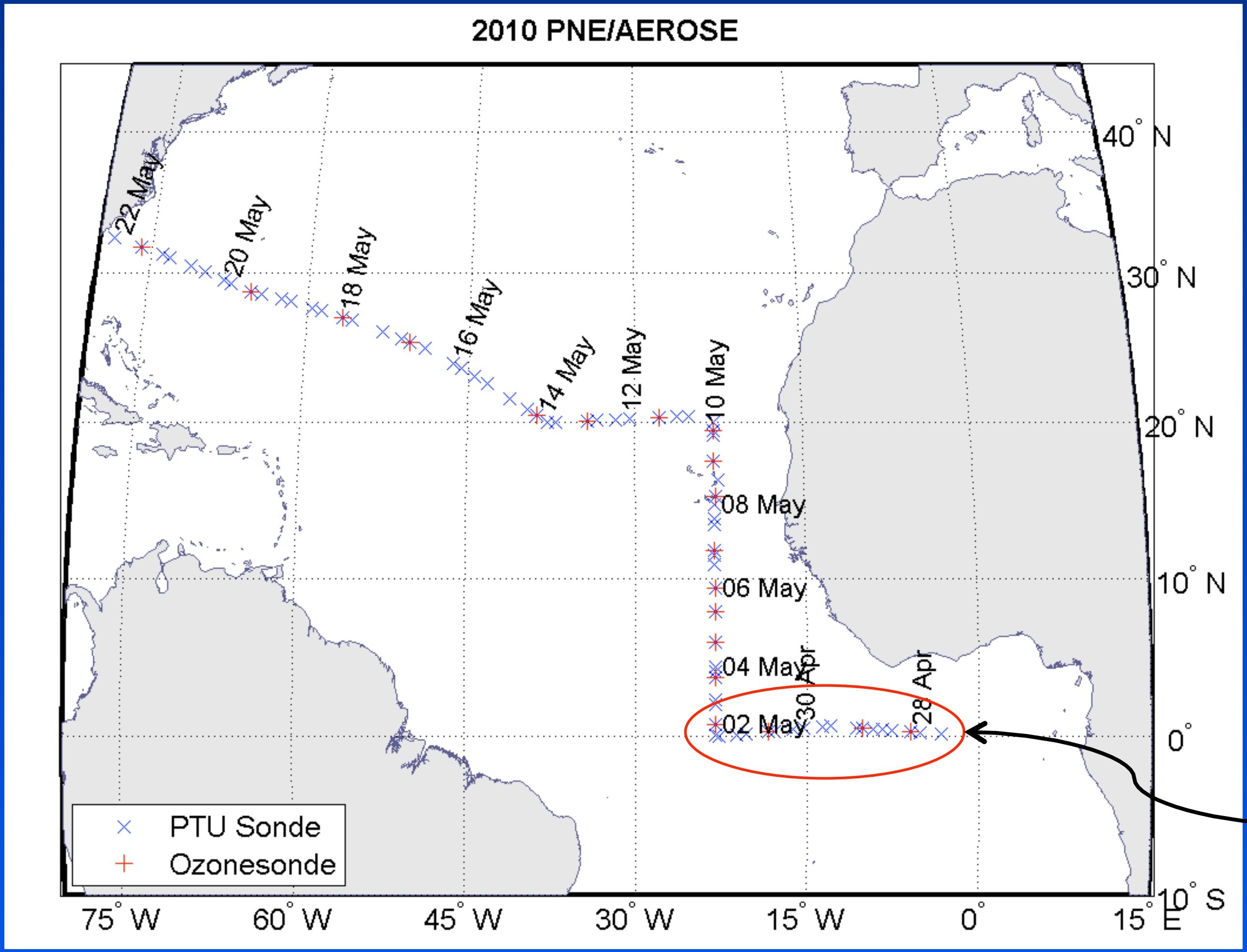
2010 PNE/AEROSE Campaign

RAOB-IASI SOUNDING CROSS-SECTIONS

2010 AEROSE RAOB-IASI Matchups

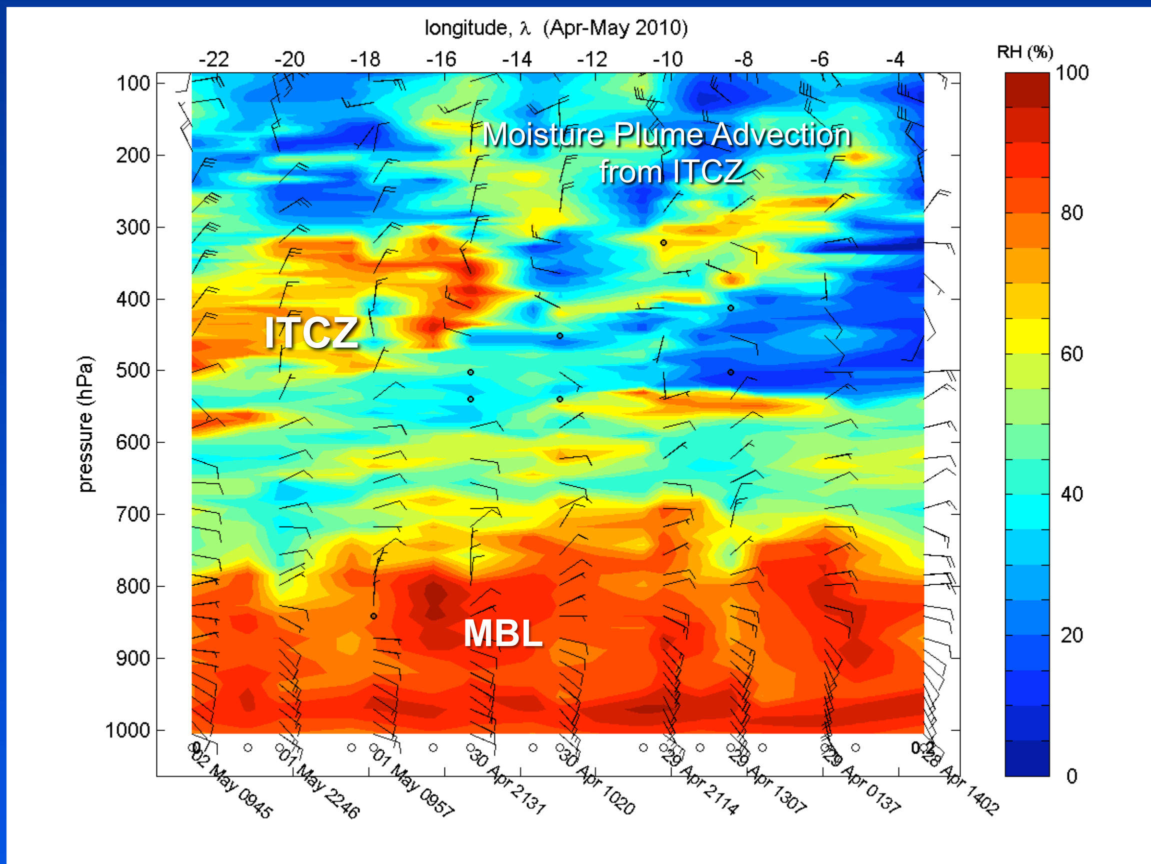


Equatorial EW1 RAOB Cross-Sections: Gulf of Guinea

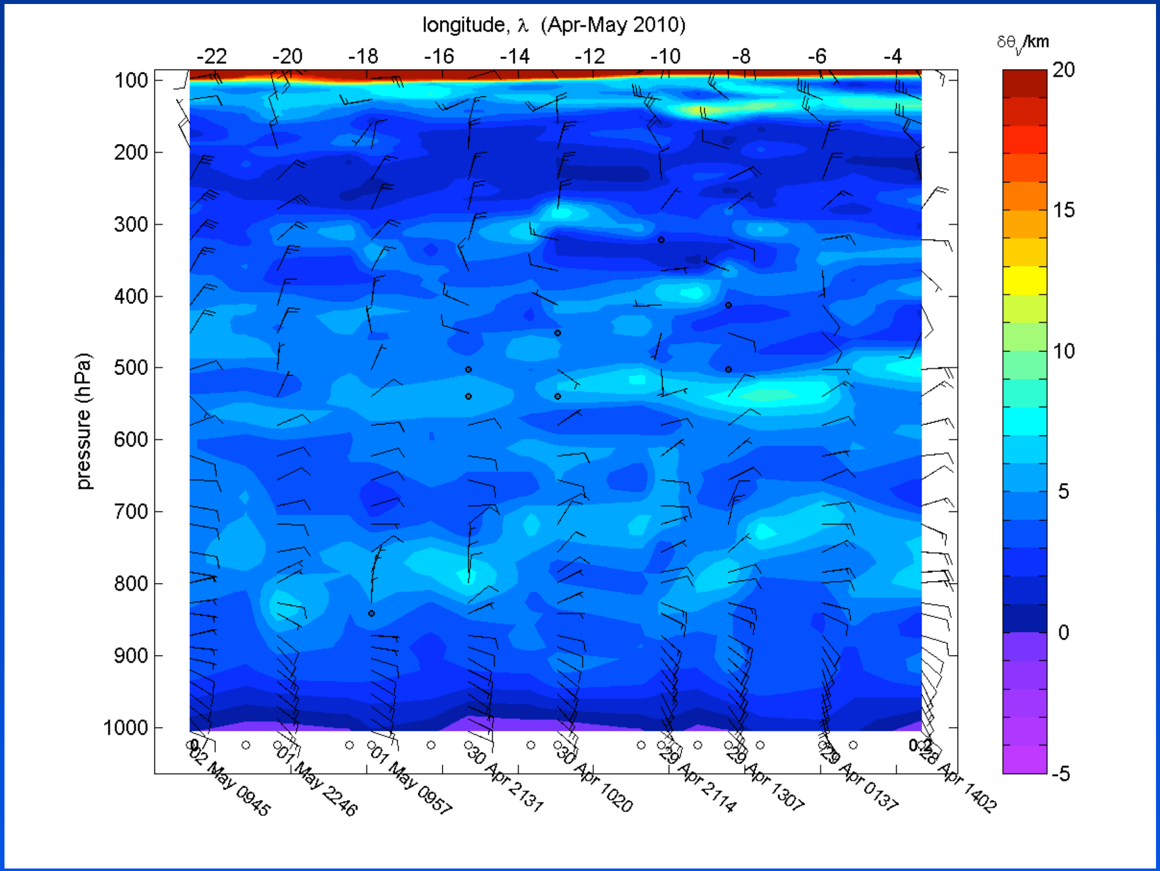


Gulf of Guinea Equatorial E-W Transect

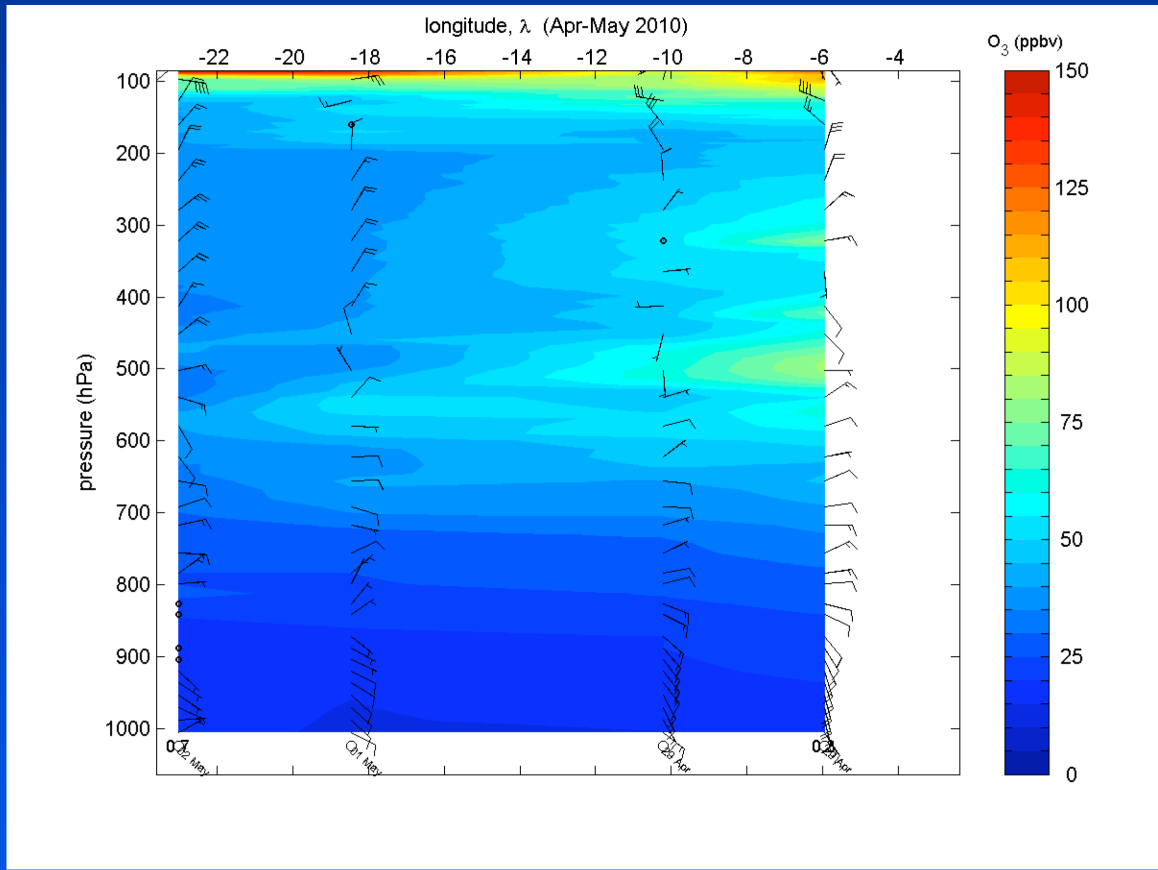
RAOB Tropospheric EW1 X-Sections 1/3 H_2O (RH)



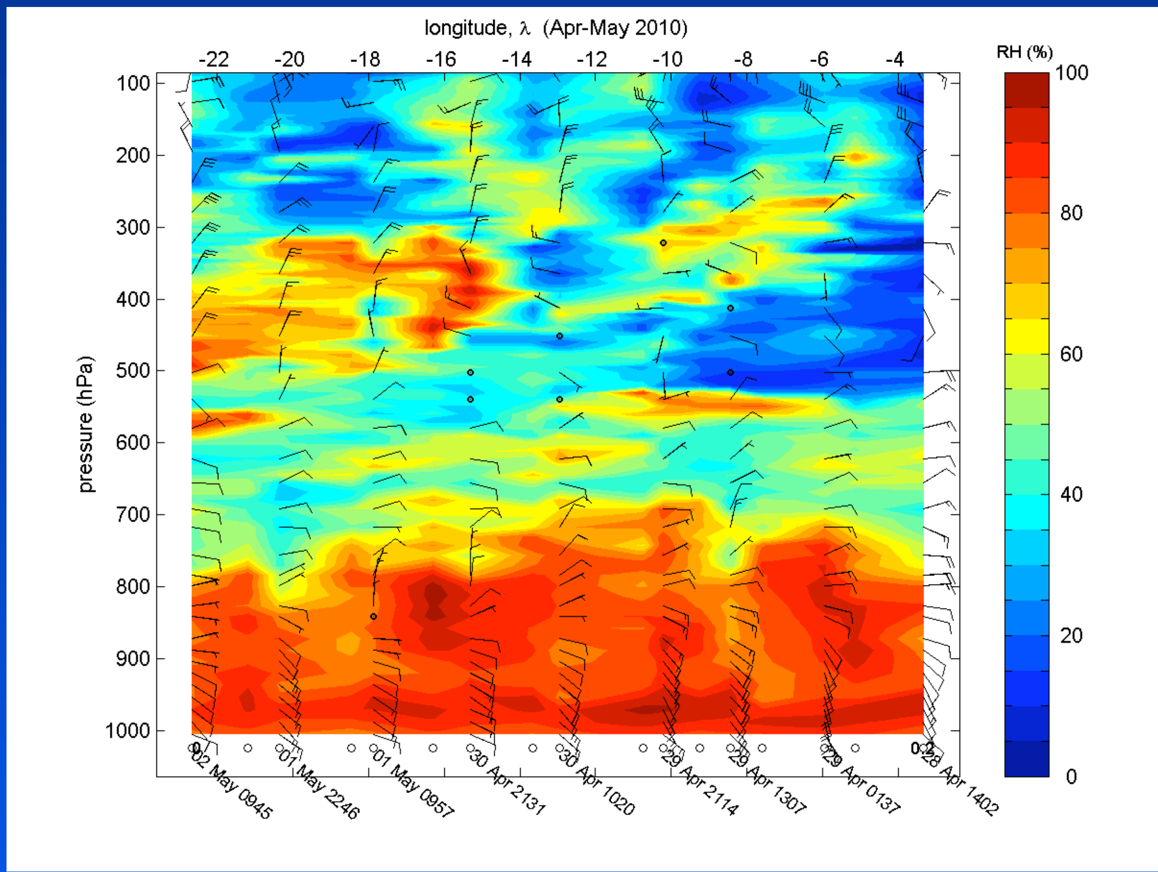
RAOB Tropospheric EW1 X-Sections 2/3
VPTLR (Static Stability)



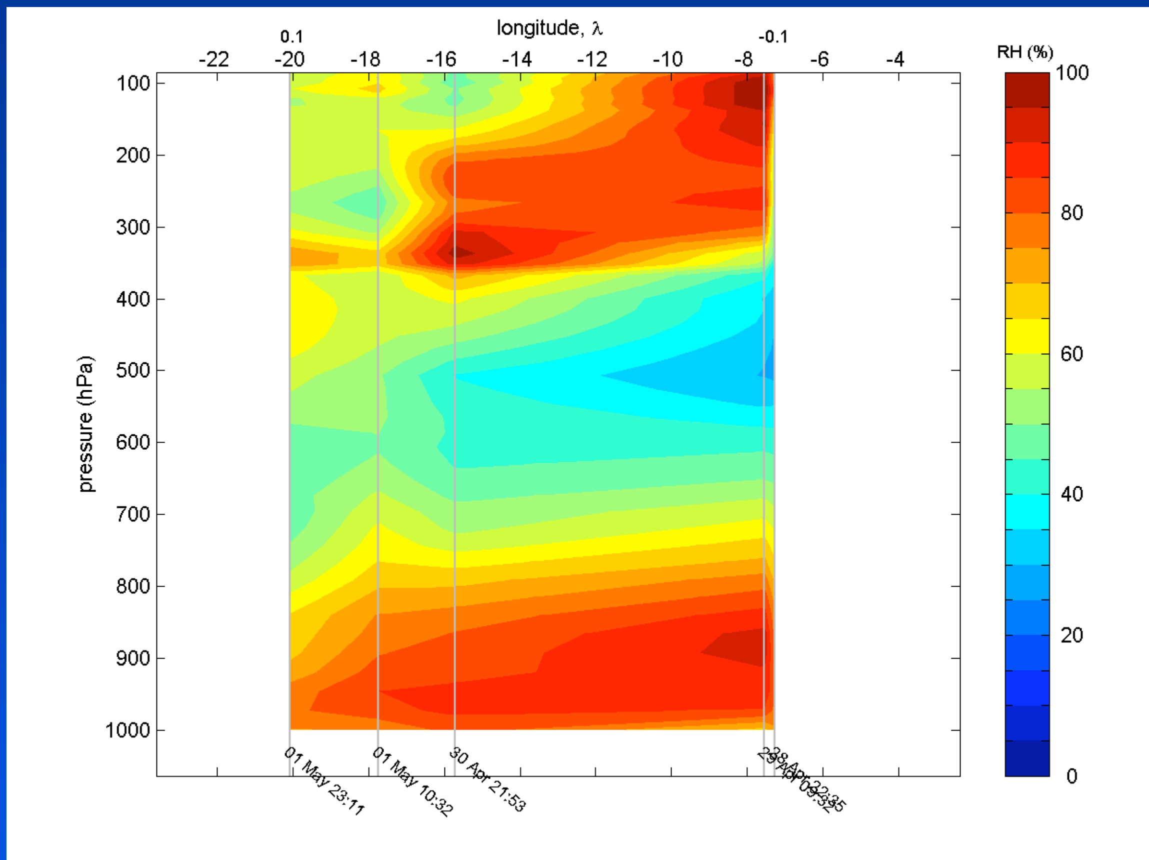
RAOB Tropospheric EW1 X-Sections 3/3
O_3 (ozone mass mixing ratio)



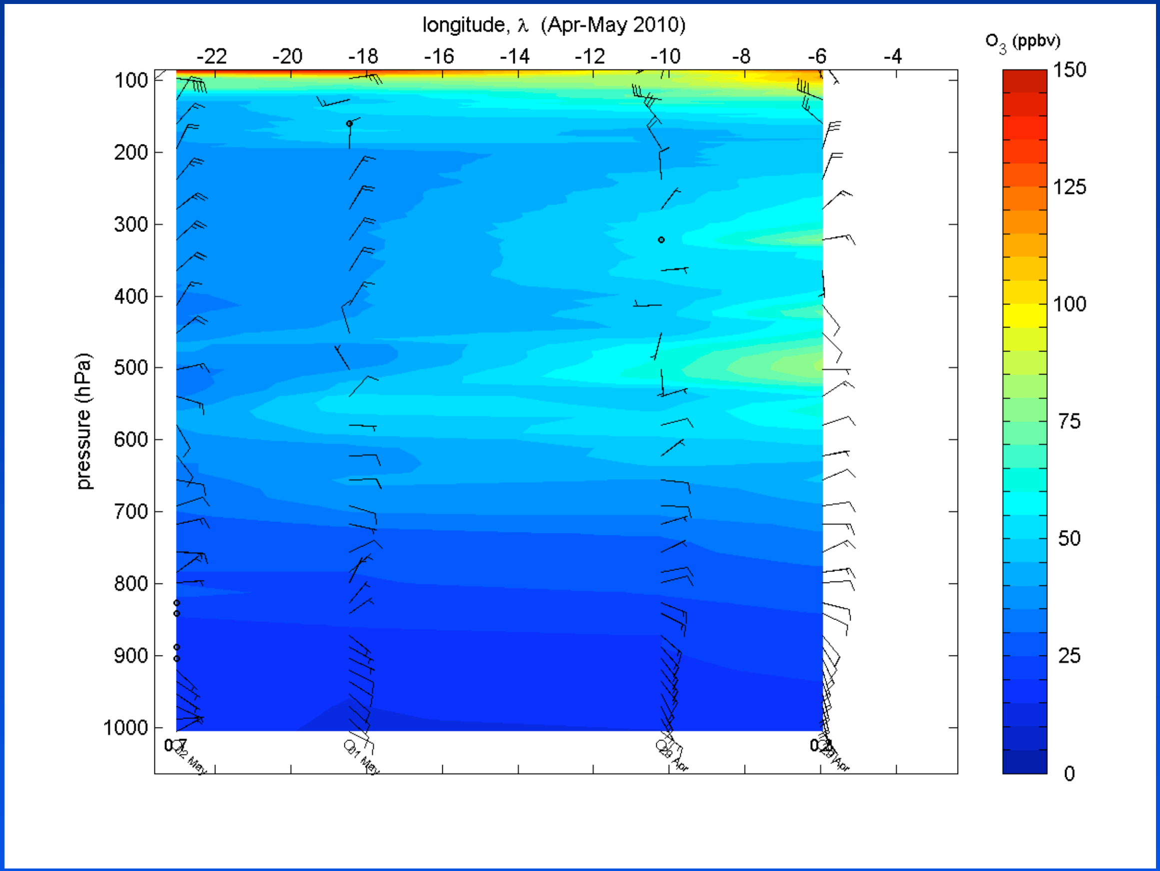
RAOB-IASI RH Comparison 1/2
RAOB EW1 cross-section



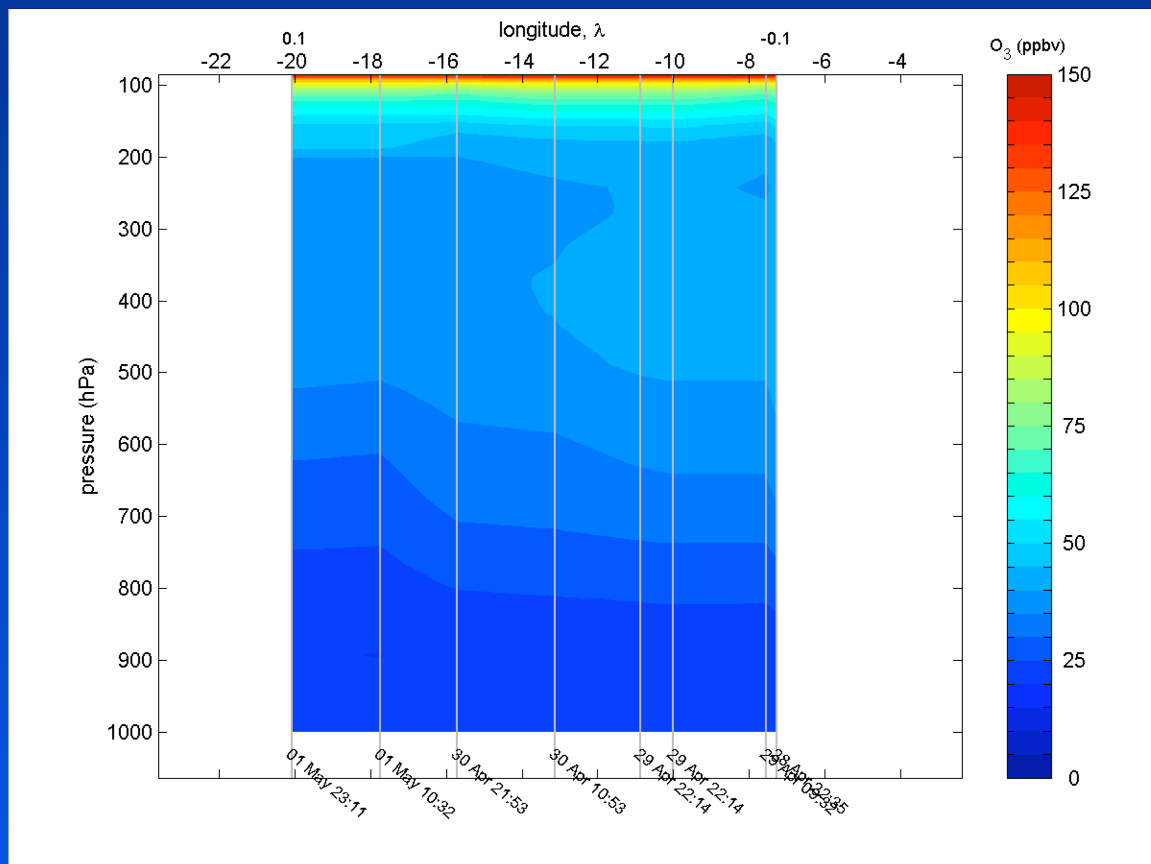
RAOB-IASI RH Comparison 2/2
IASI-L2 (QA) EW1 cross-section



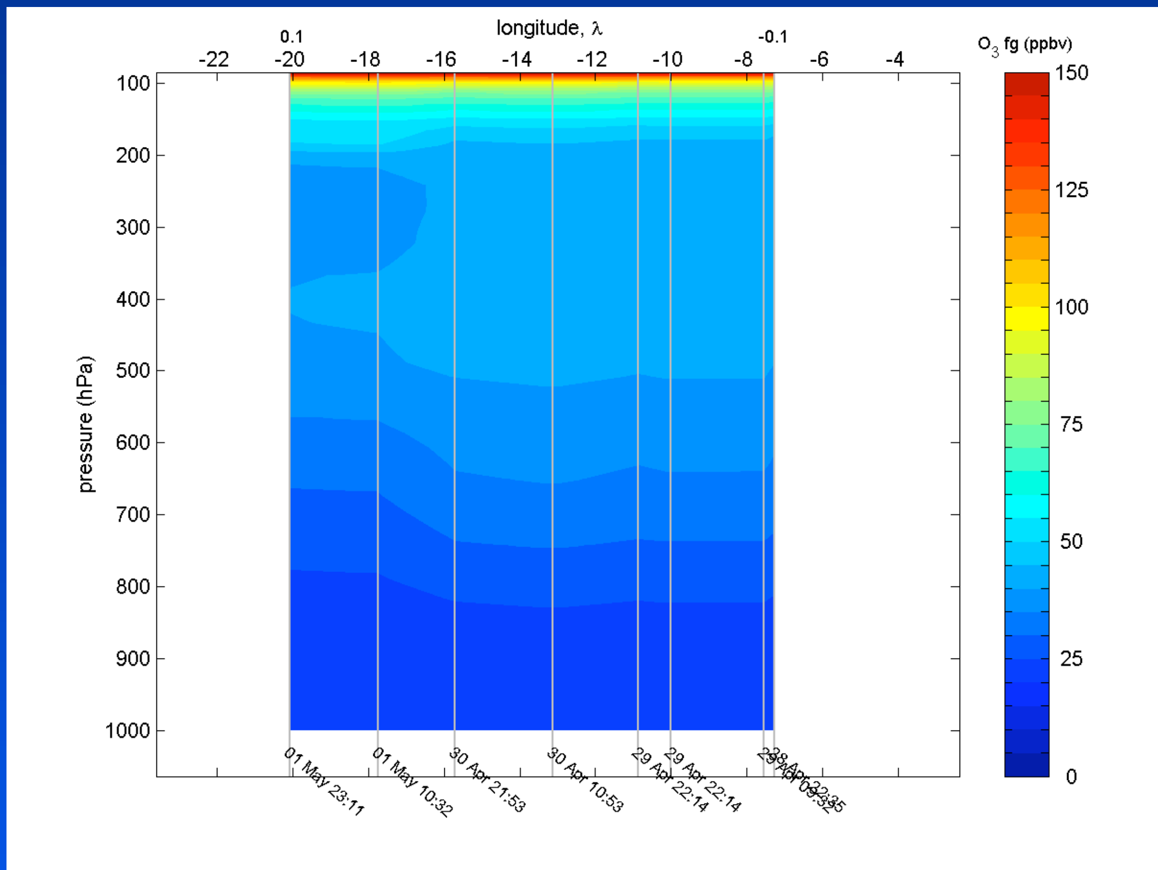
RAOB-IASI O_3 Comparison 1/3
RAOB EW1 cross-section



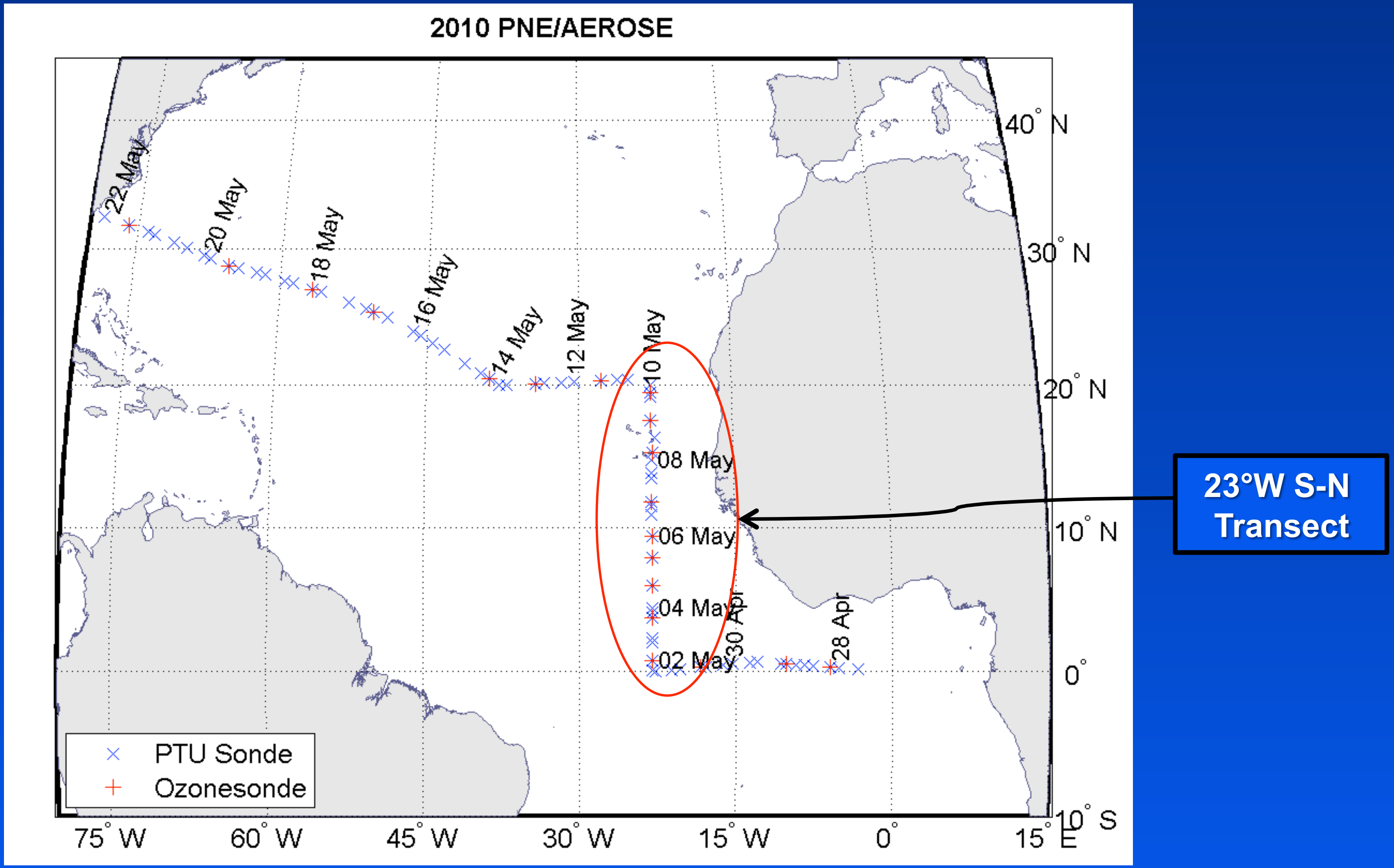
RAOB-IASI O_3 Comparison 3/3
IASI-L2 (no-QA) EW1 cross-section



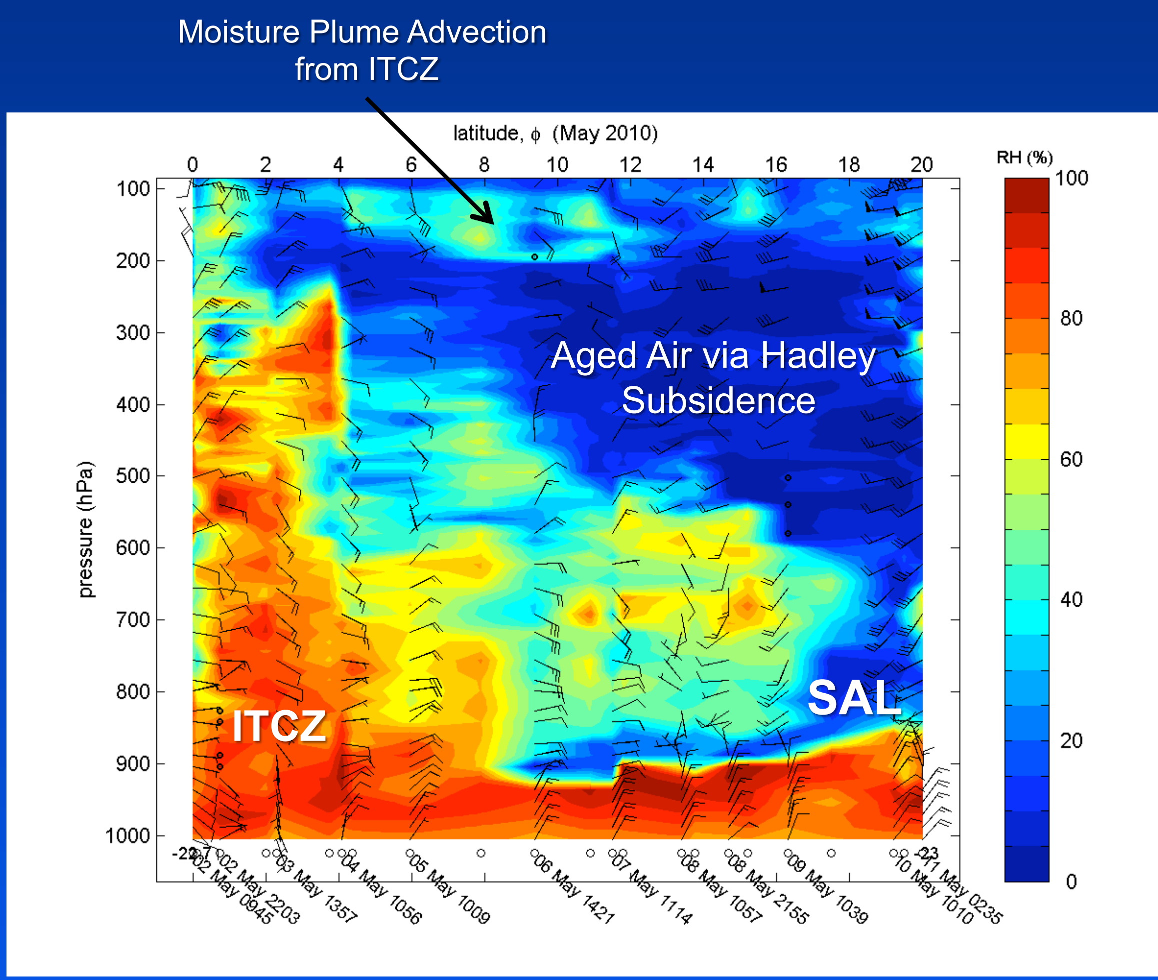
RAOB-IASI O_3 Comparison 2/3
IASI-FG (no-QA) EW1 cross-section



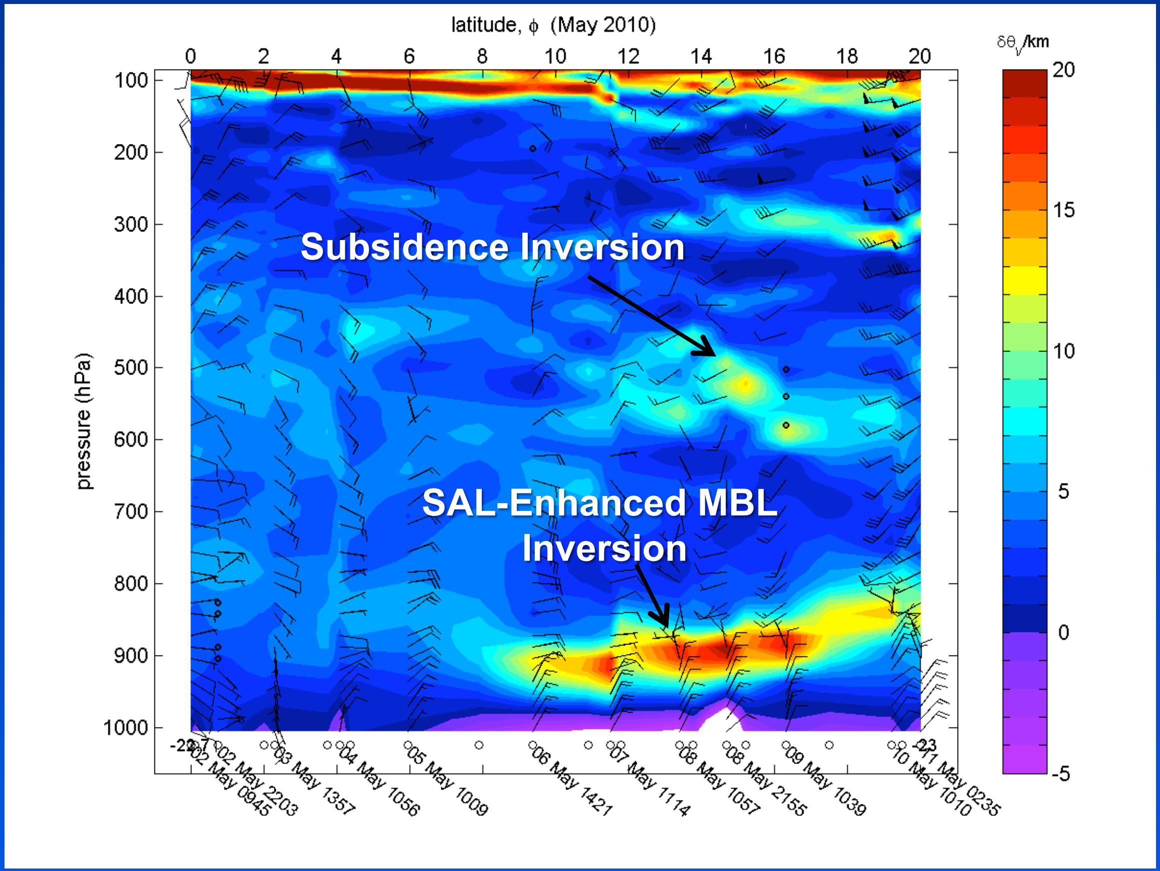
23°W SN RAOB Cross-Sections: Tropical North Atlantic



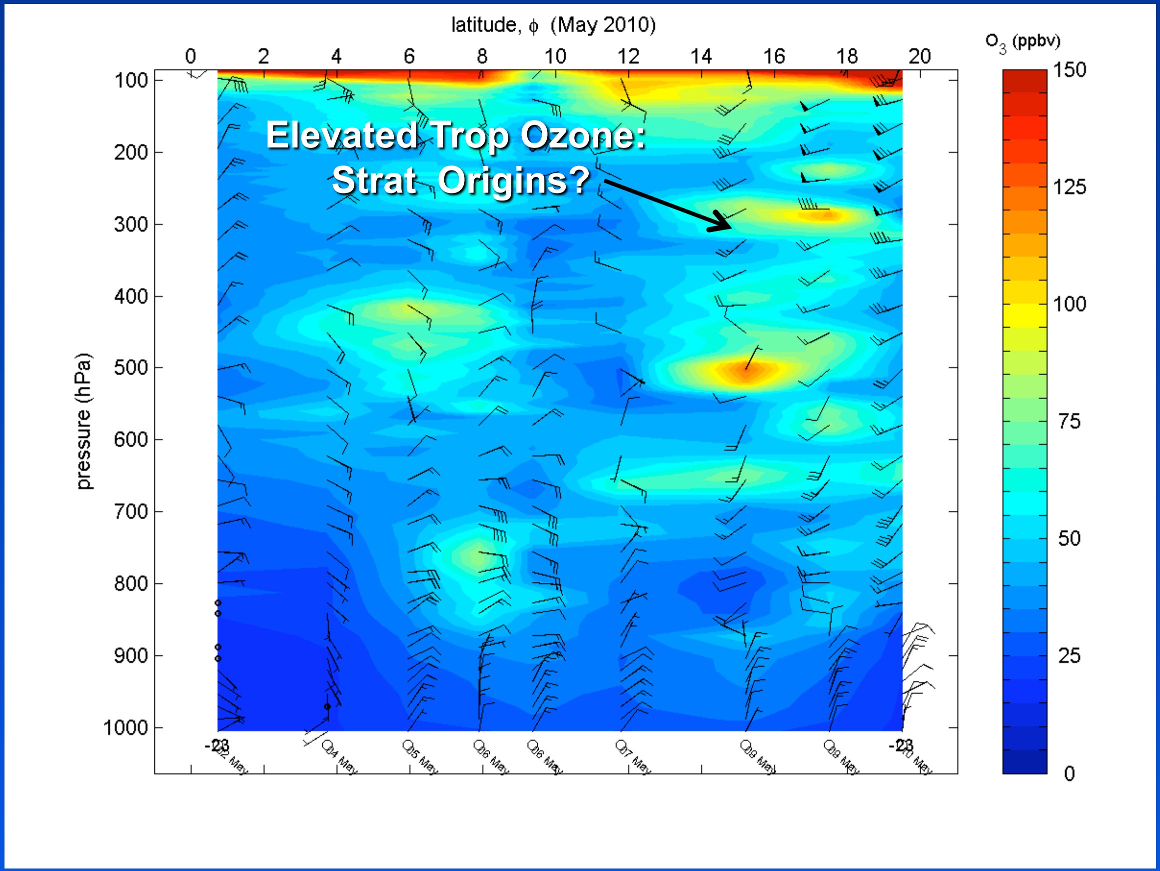
RAOB Tropospheric SN X-Sections 1/3 H_2O (RH)



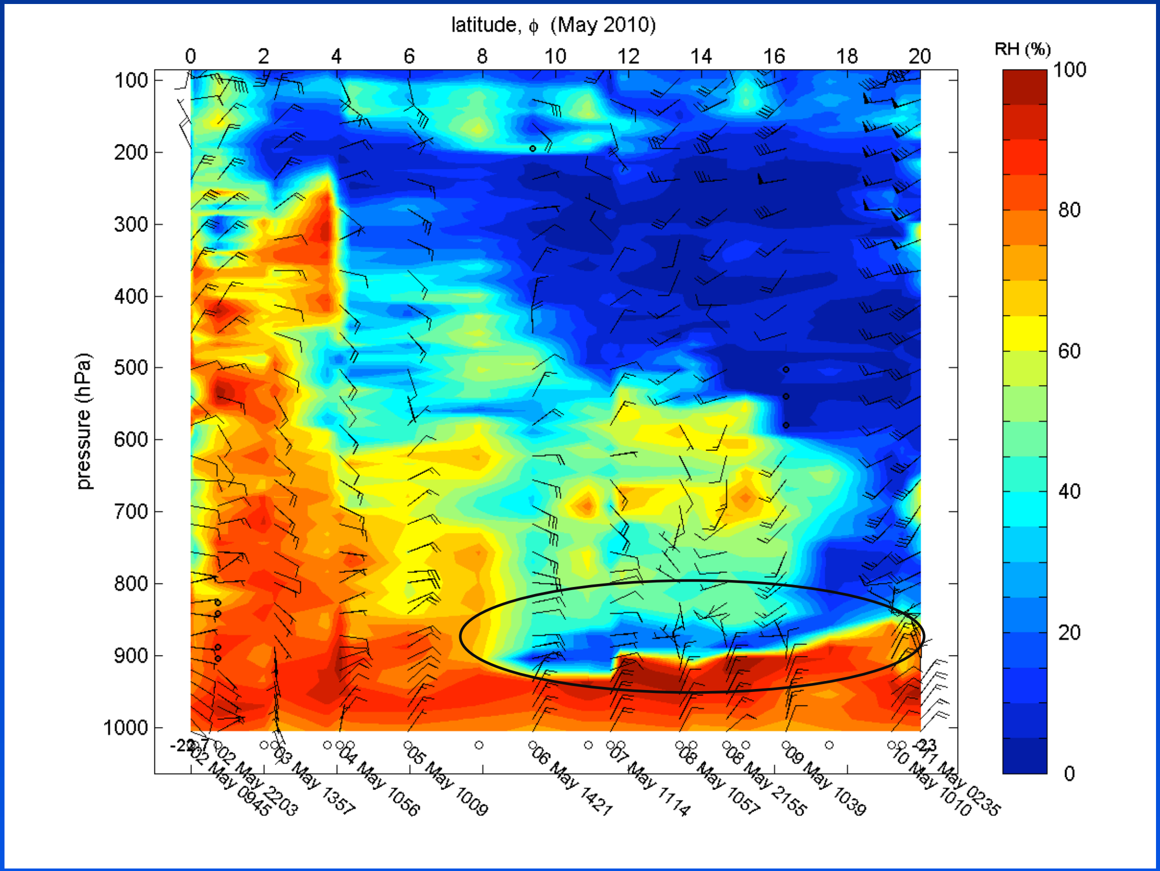
RAOB Tropospheric SN X-Sections 2/3
VPTLR (Static Stability)



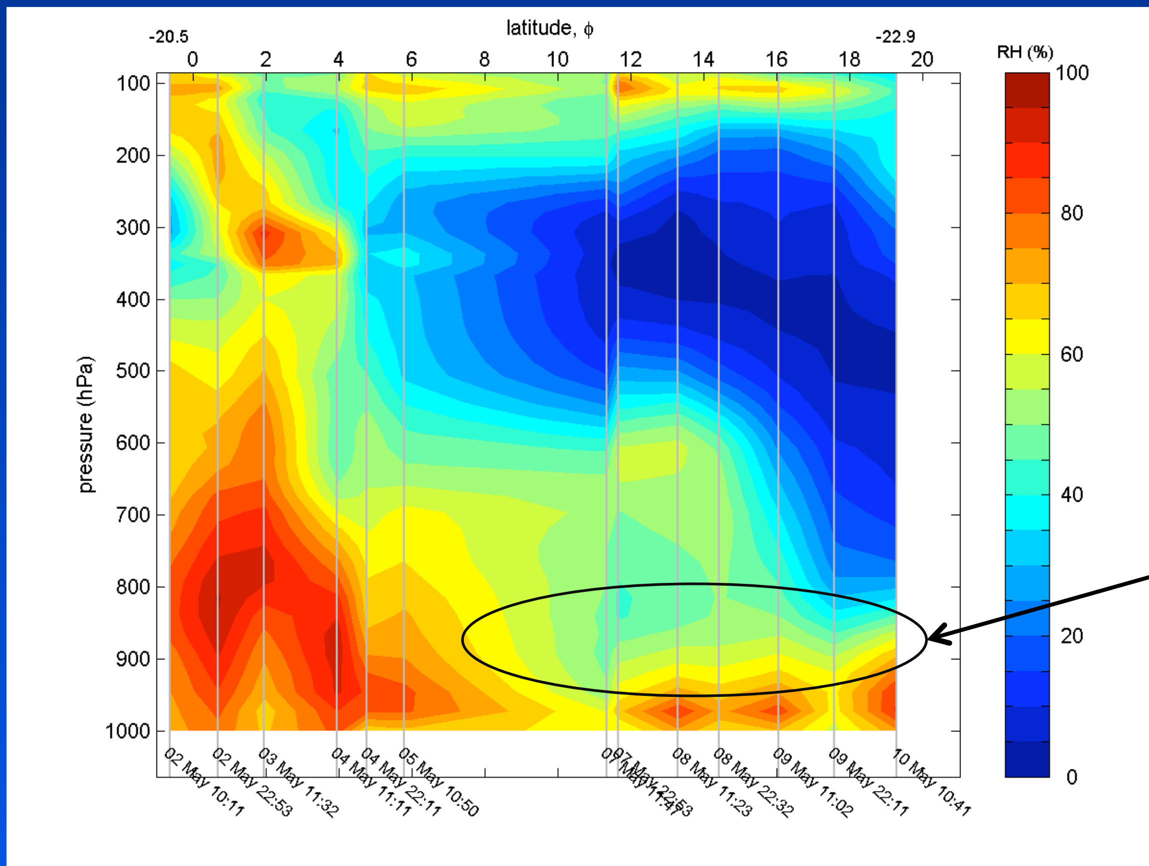
RAOB Tropospheric SN X-Sections 3/3
O_3 (ozone mass mixing ratio)



RAOB-IASI RH Comparison 1/2
RAOB SN cross-section

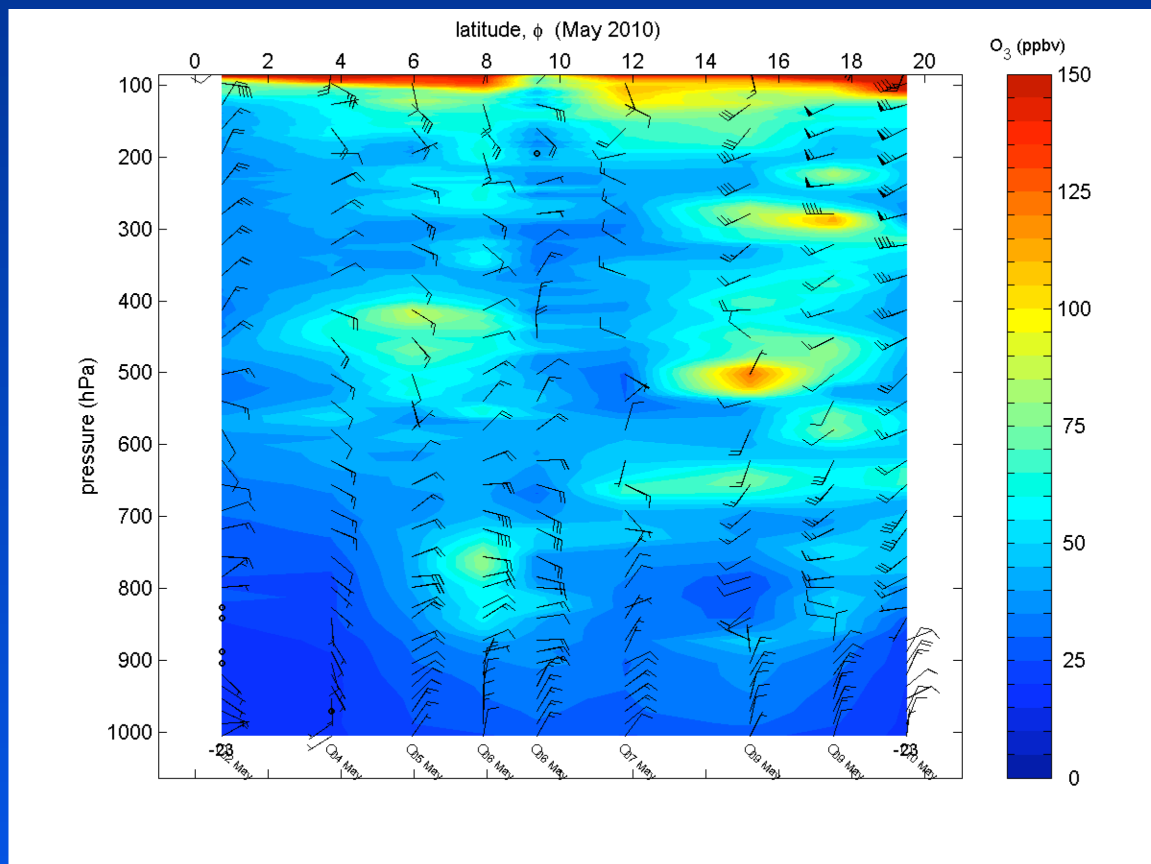


RAOB-IASI RH Comparison 2/2
IASI-L2 (QA) SN cross-section

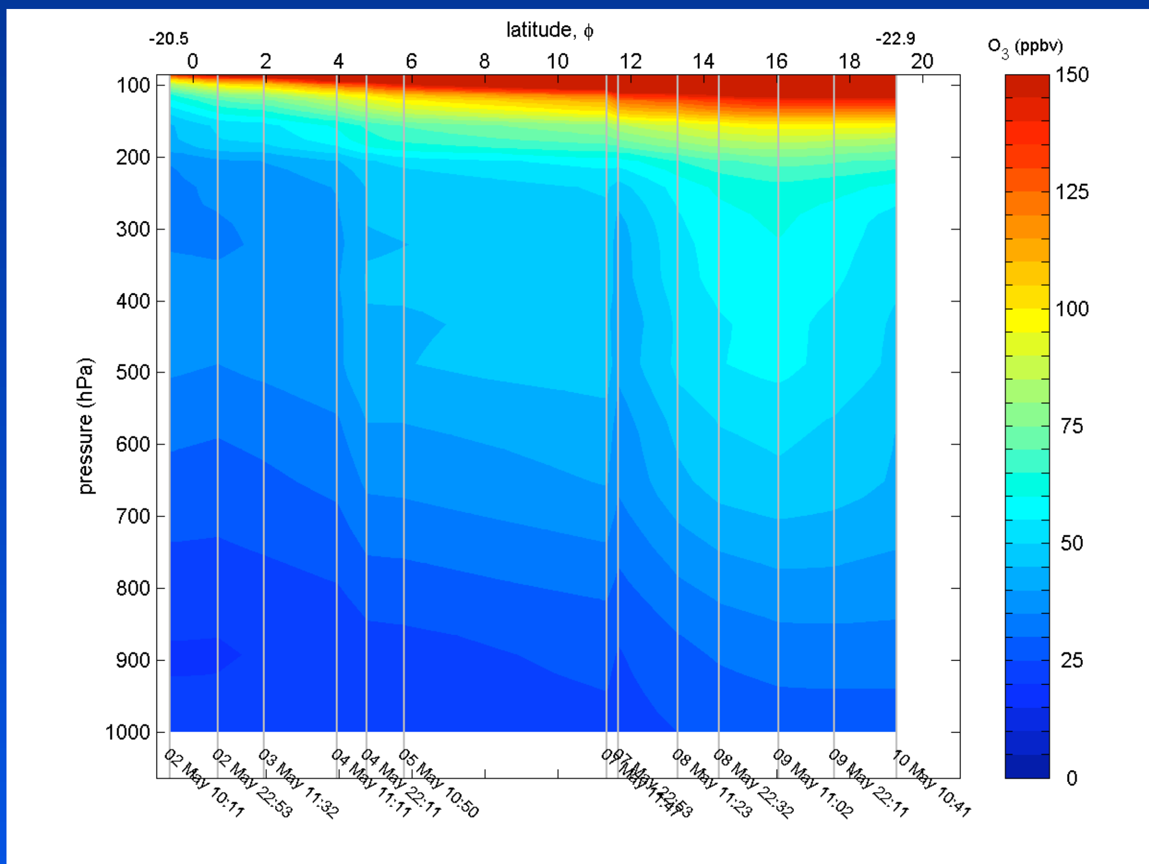


Unfortunately, in this case, the very shallow (~0.5 km) **SAL** “dry filament” was not detected

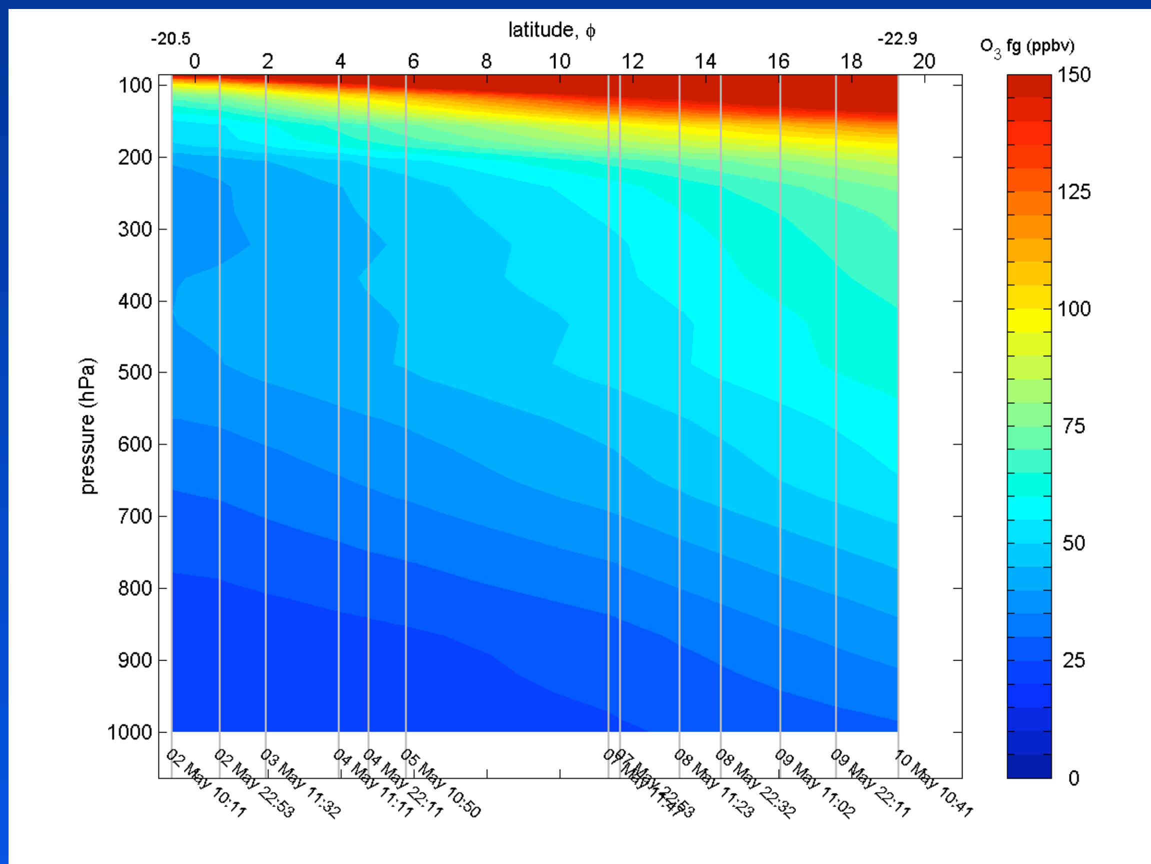
RAOB-IASI O_3 Comparison 1/3
RAOB SN cross-section



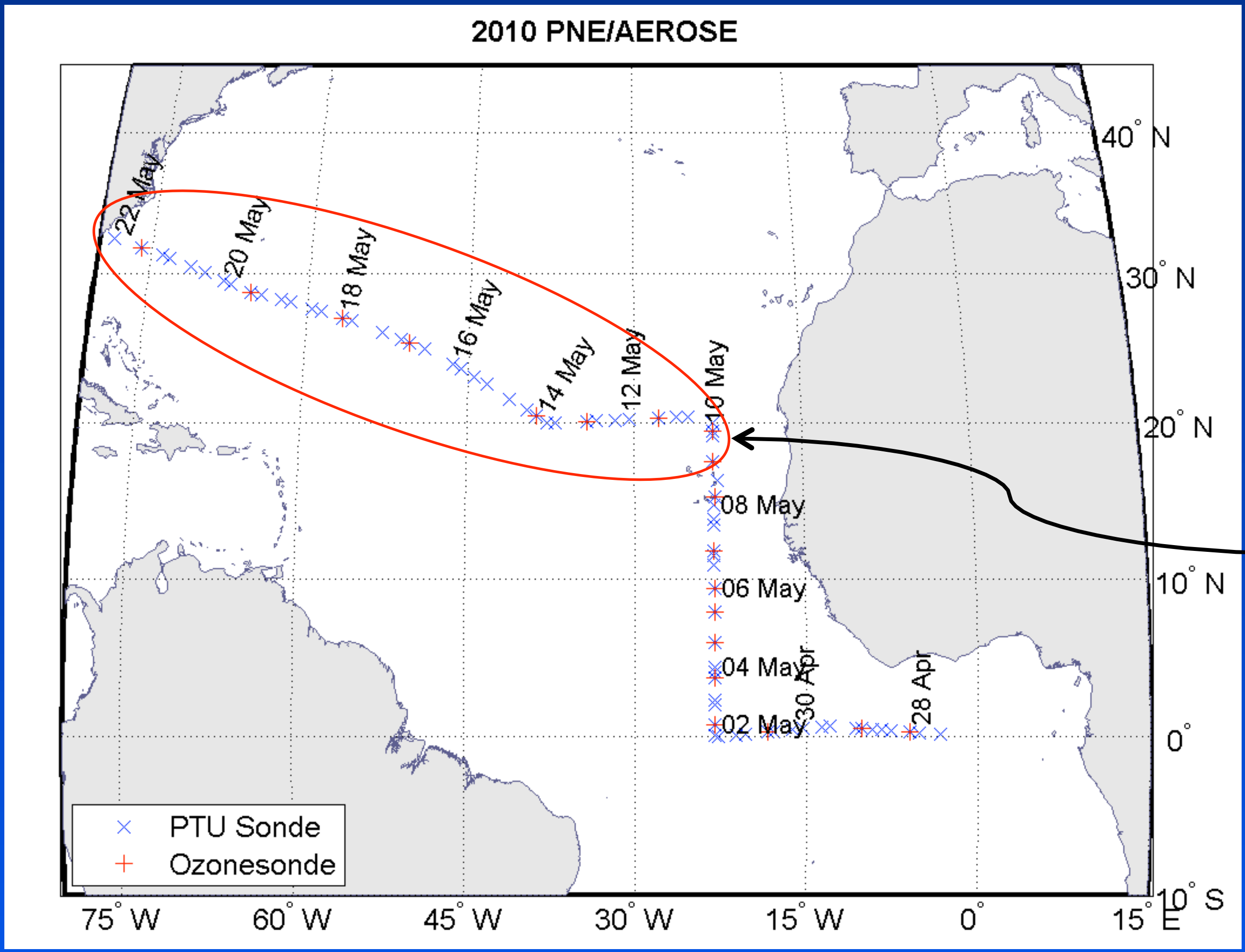
RAOB-IASI O_3 Comparison 2/3
IASI-L2 (QA) SN cross-section



RAOB-IASI O_3 Comparison 2/3
IASI-FG (QA) SN cross-section

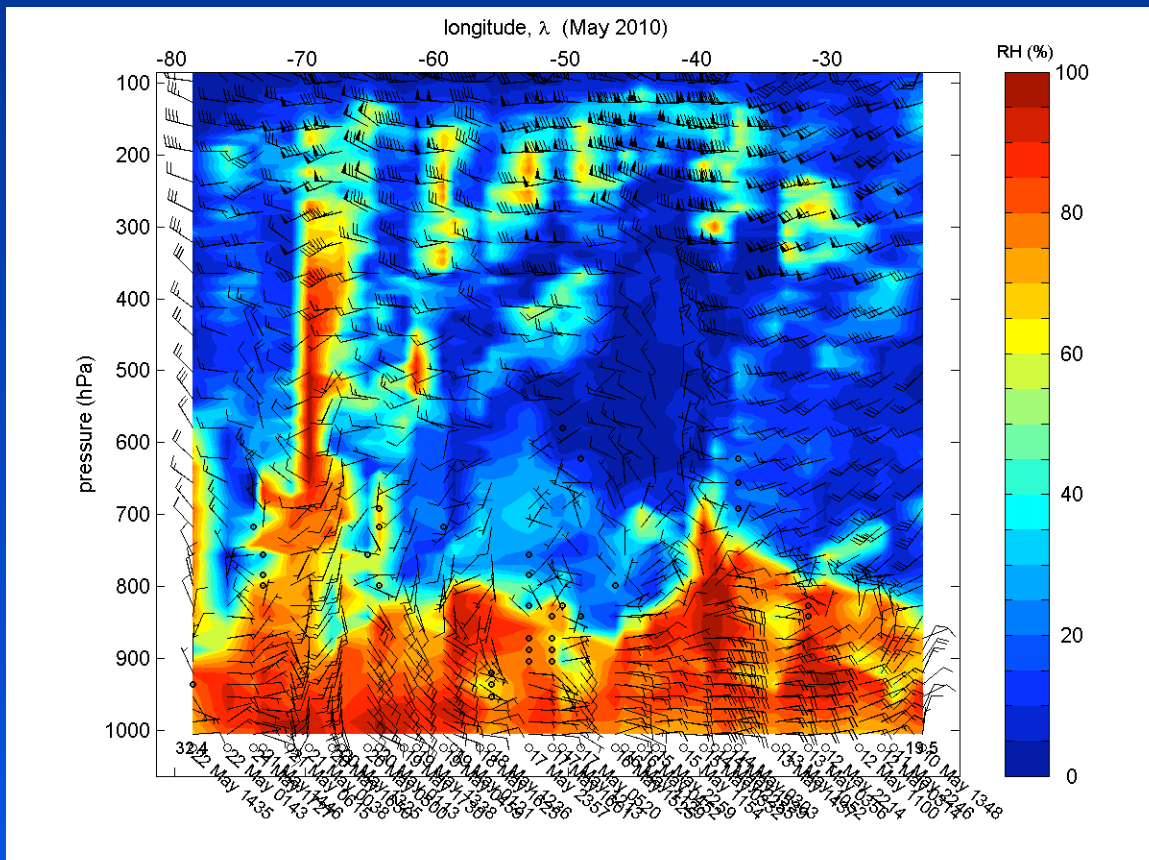


20-32°N EW2 RAOB Cross-Sections: Tropical North Atlantic

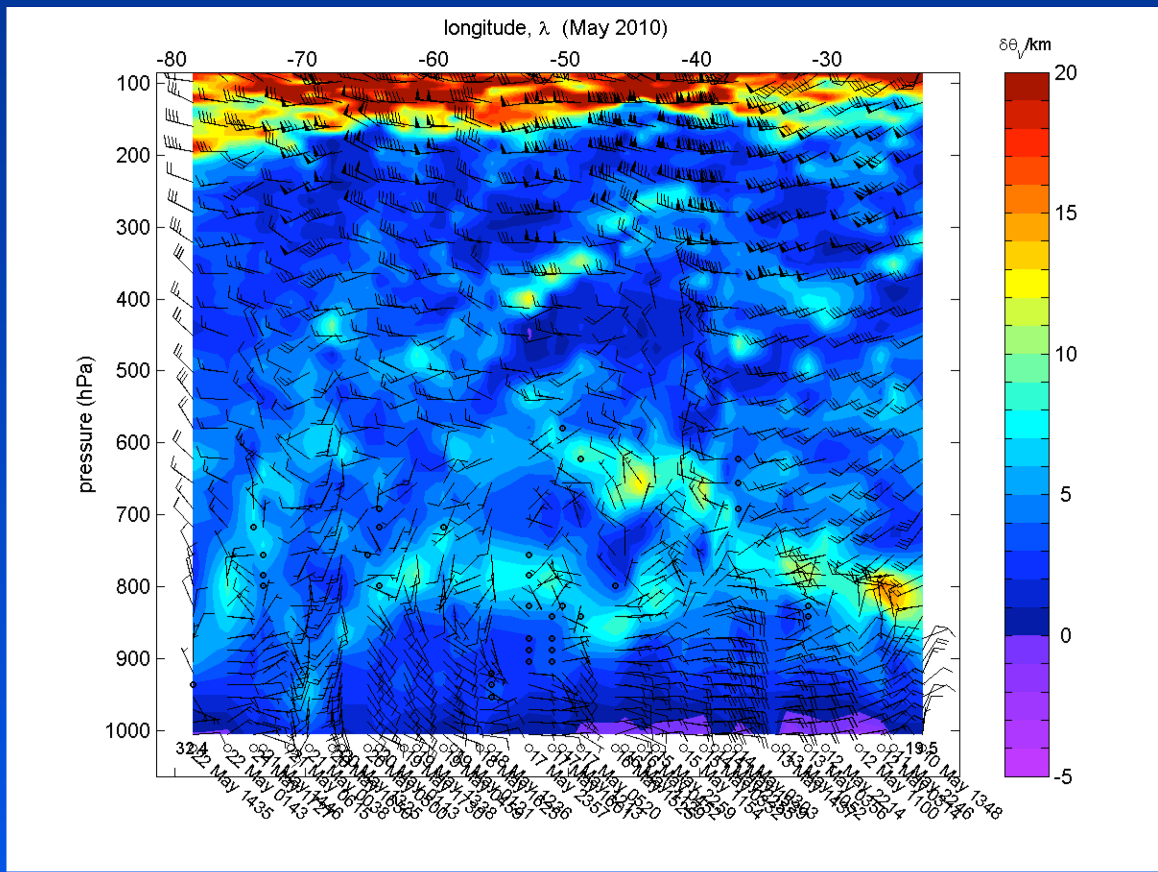


20-32°N E-W Transect

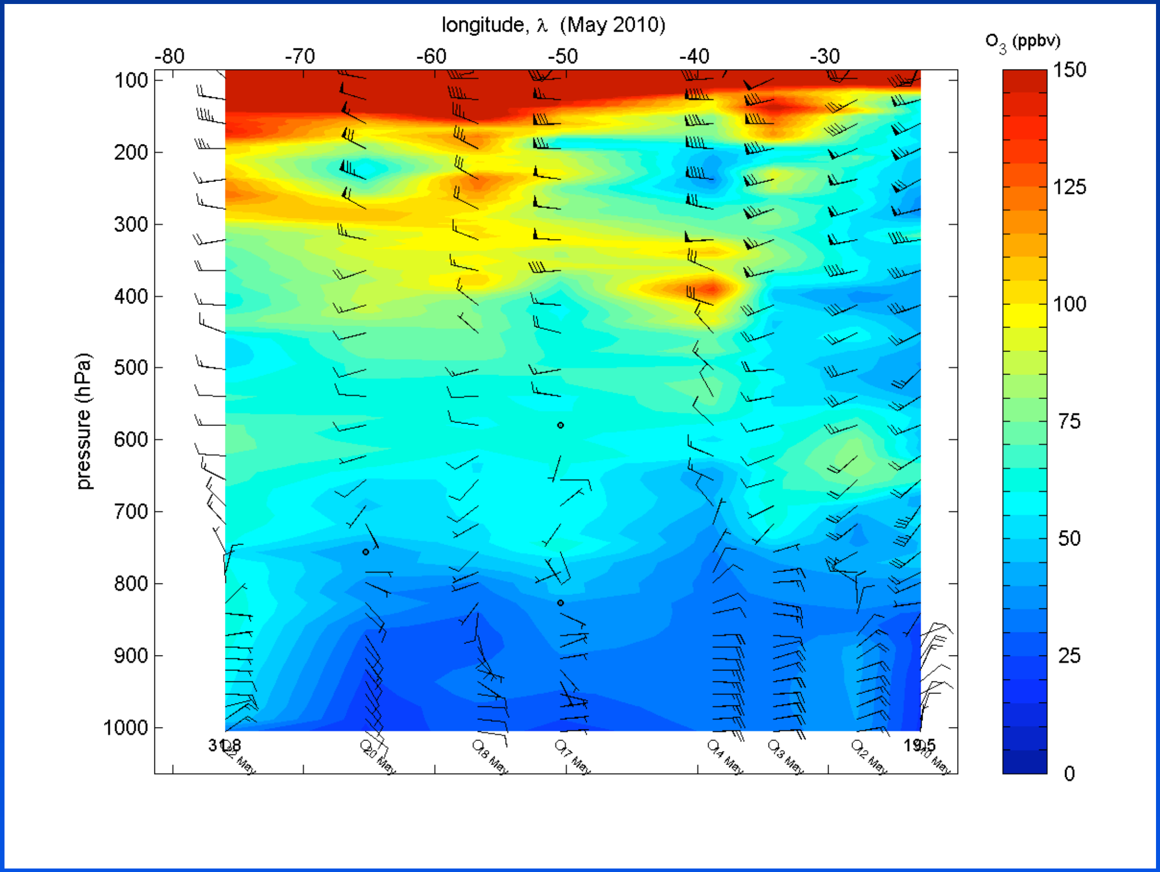
RAOB Tropospheric EW2 X-Sections 1/3 H_2O (RH)



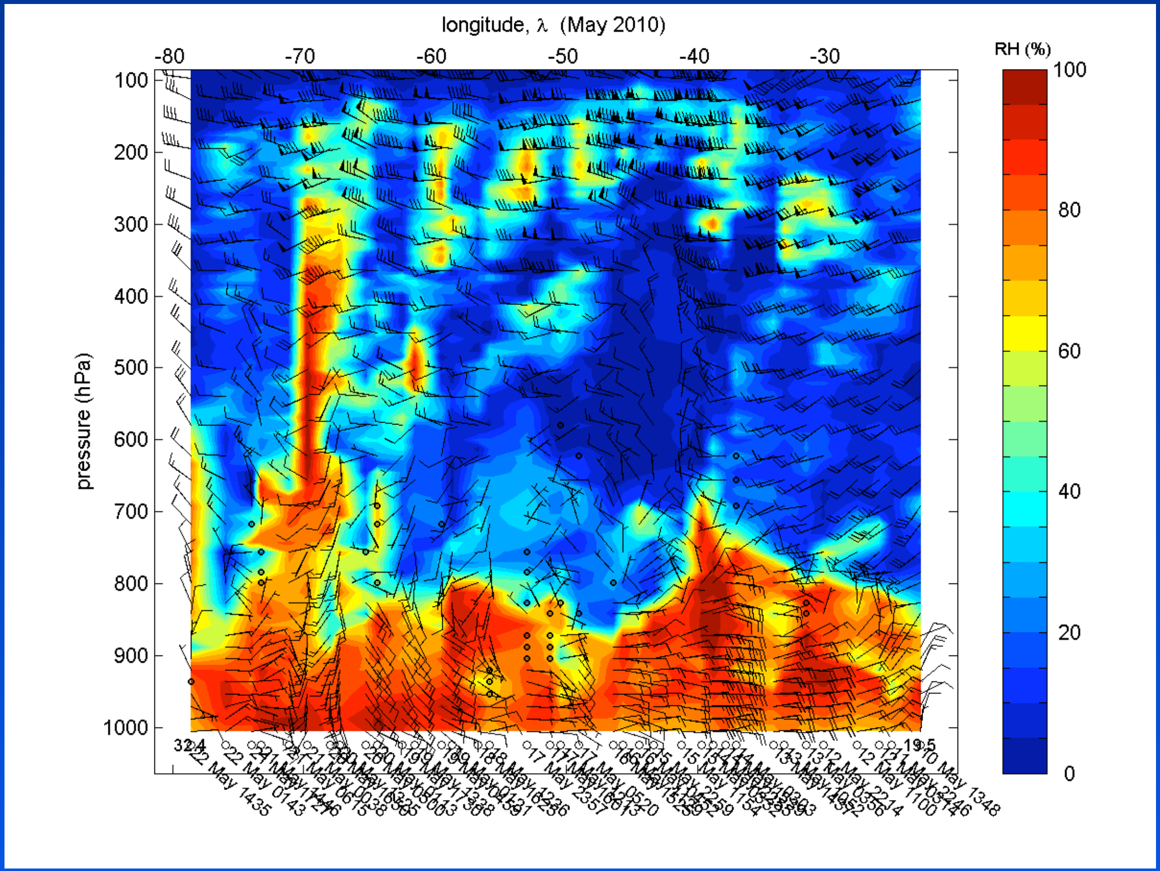
RAOB Tropospheric EW2 X-Sections 2/3
VPTLR (Static Stability)



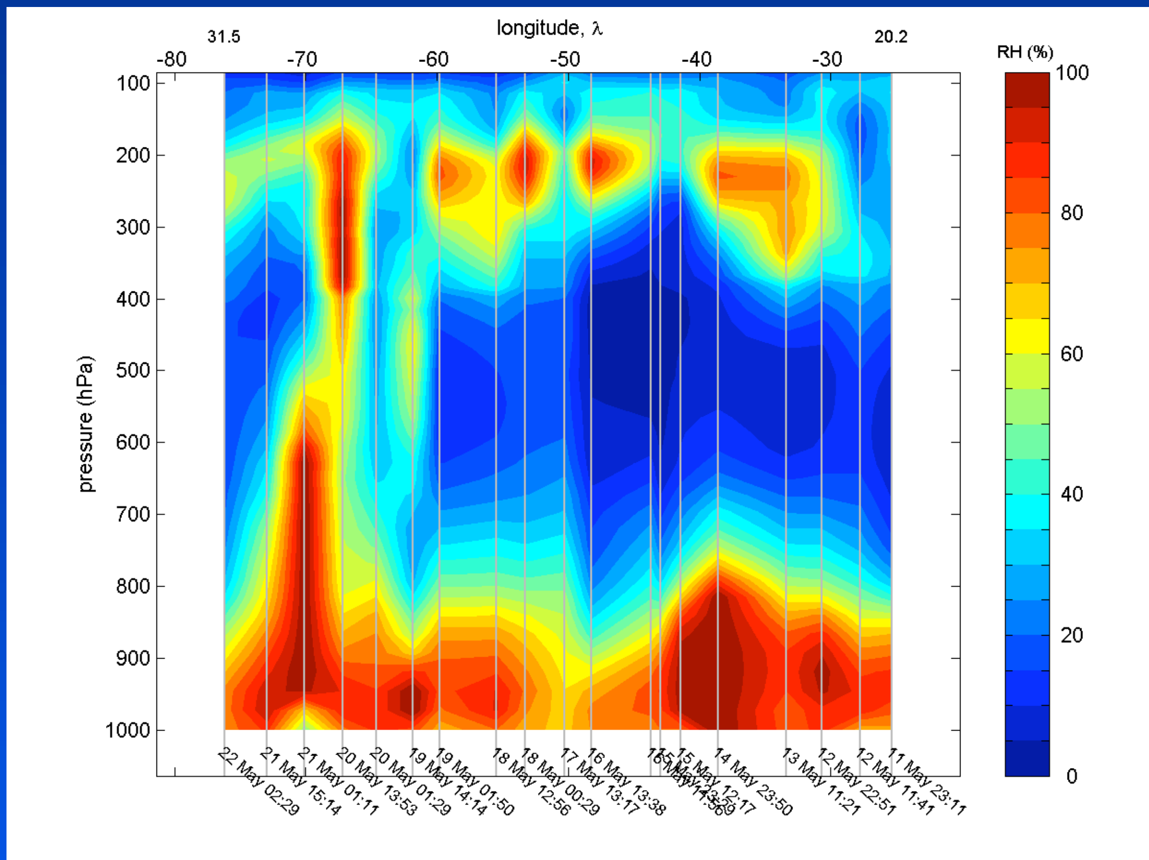
RAOB Tropospheric EW2 X-Sections 3/3
O_3 (ozone mass mixing ratio)



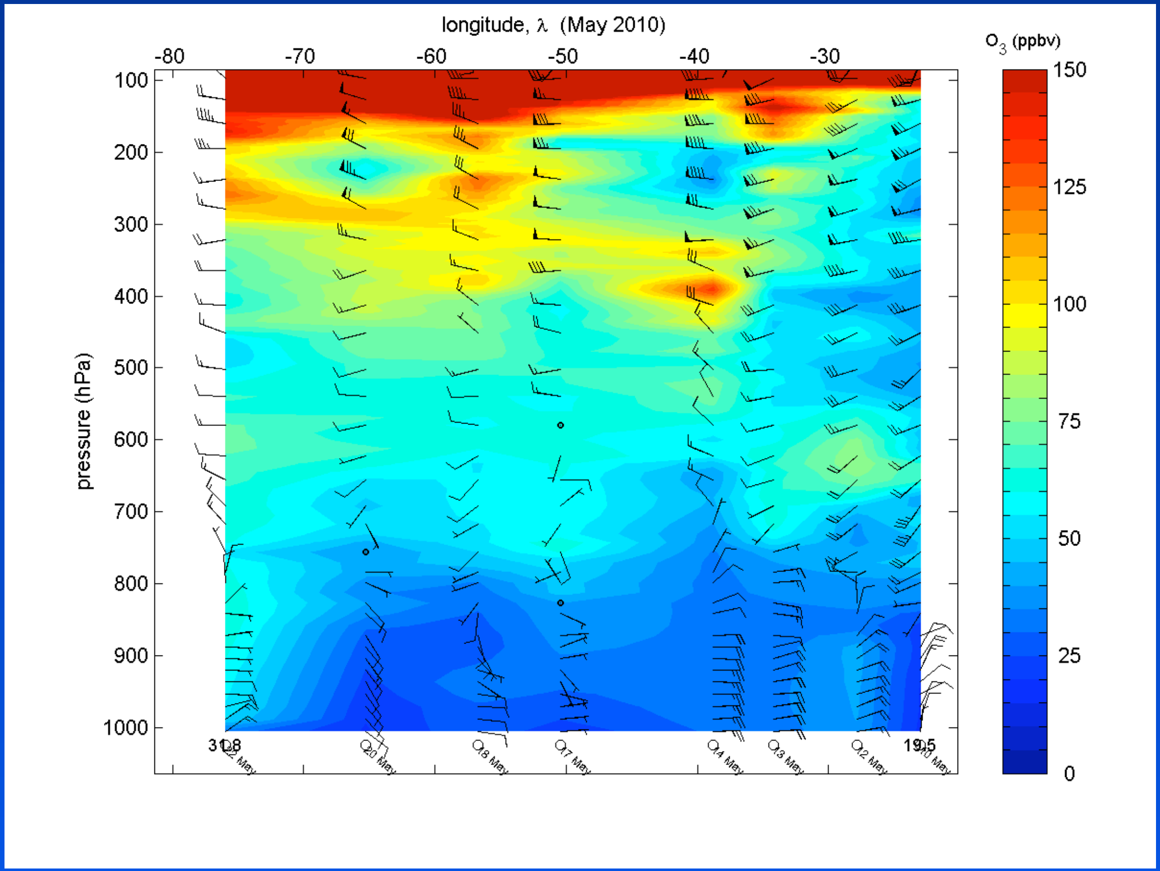
RAOB-IASI RH Comparison 1/2
RAOB E-W cross-section



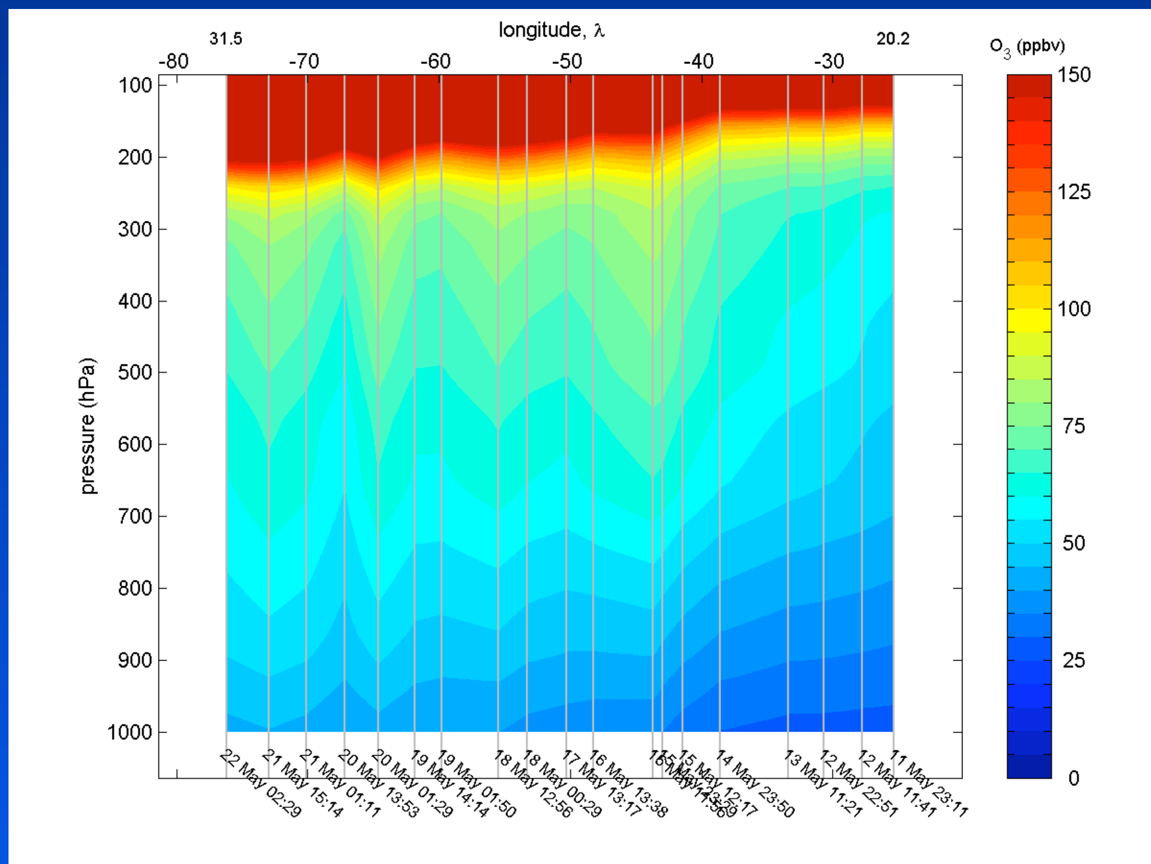
RAOB-IASI RH Comparison 2/2
IASI-L2 (no-QA) EW2 cross-section



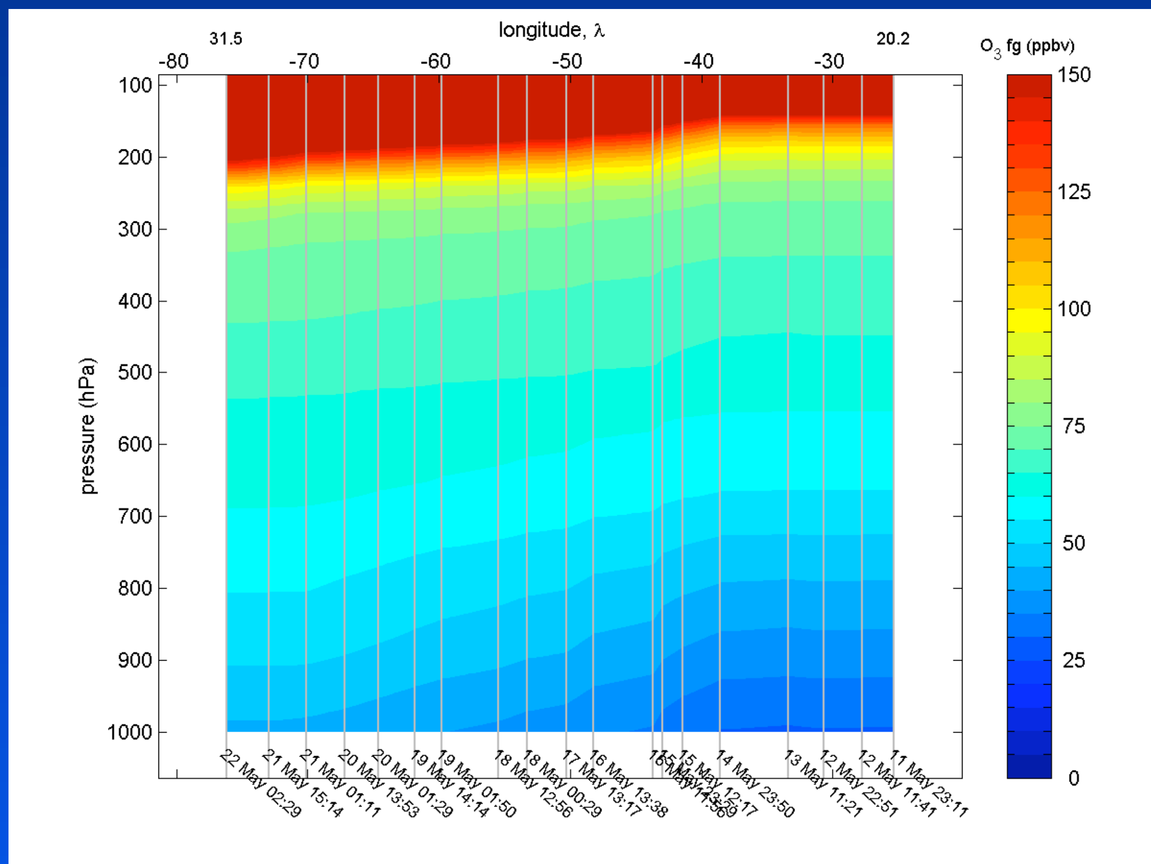
RAOB-IASI O_3 Comparison 1/3
RAOB EW2 cross-section



RAOB-IASI O_3 Comparison 3/3
IASI-L2 (no-QA) EW2 cross-section



RAOB-IASI O_3 Comparison 2/3
IASI-FG (no-QA) EW2 cross-section



Summary

- The **NOAA PNE/AEROSE** intensive campaigns continue to compile a multiyear set of ship-based, marine *in situ* **cross-sectional correlative measurements** (IASI, AIRS and SEVIRI matchups) over the tropical Atlantic Ocean.
  - The 2010 campaign added to the current data inventory from 2004, 2006–2009.
- The AEROSE domain spans a **region of marine meteorological interest** (for sounder missions) in terms of the SAL, tropical storm formation, and tropospheric ozone/carbon/aerosol chemistry and transport.
- **2010 AEROSE highlights** include
  - 2 zonal and 1 meridional cross-sections
  - Unique sampling of the Gulf of Guinea
  - Preliminary **IASI L2 x-sections** show **reasonable coherent space-time agreement** w RAOB x-sections
    - Surprisingly good tropospheric ozone agreement – appears legit
    - Not surprisingly, a very shallow (~0.5 km) SAL “dry filament” was missed
- The next campaign is tentatively scheduled for Spring 2011.

PNE/AEROSE Ongoing and Future Research

- **Manuscript on PNE/AEROSE campaigns** (general overview with emphasis on meteorological highlights and sounder Cal/Val) currently **in peer-review for *BAMS*** (*Nalli et al.*).
- **Construct 2009, 2010 AEROSE CrIS/ATMS Proxy Data** (J. Wei, G. Guo, M. Divakarla, T. King, STAR).
  - AVTP, AVMP validation over open ocean, within and without Saharan air layer, dust, smoke
  - IP validation: vertical ozone profiles, skin SSTs
- Construct 2010 AEROSE GOES-R Proxy Data Set, including SEVIRI, AIRS/IASI granules (H. Xie, T. Zhu).
  - SEVIRI/GOES-R ABI legacy profile TPW validation and demonstration; SAL detection (H. Xie, J. Li)
- Acquisition of satellite matchup data within NPROVS (T. Reale, STAR); AIRS dedicated global analysis (E. Fetzer, S. Wong, JPL).
- Focused retrieval "dissections" (isolating the error sources rather than merely proving a final product statistic) using combined AEROSE datasets (E. Maddy, C. Barnet).
- Aerosol IR retrieval/modeling studies (Sergio, UMBC).
- In depth studies of AEROSE data
  - SAL characterization in the eastern Atlantic basin)
  - Impact on tropical Atlantic radiative flux
  - SST response to radiative forcing
  - 2009 TS Ana, which was "suppressed", tropospheric ozone, etc.)
  - Tropospheric Ozone dynamics: Wave-one "paradox", Strat Intrusions (L. Pan)
- Other possibilities?

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